Calhoun

Institutional Archive of the Naval Postgraduate School

**Calhoun: The NPS Institutional Archive**

**DSpace Repository**

Theses and Dissertations | 1. Thesis and Dissertation Collection, all items

1978

# The development and implementation of algorithms for an A-7E performance calculator.

Koger, Gary Lang

Monterey, California. Naval Postgraduate School

http://hdl.handle.net/10945/18401

This publication is a work of the U.S. Government as defined in Title 17, United States Code, Section 101. Copyright protection is not available for this work in the United States.

*Downloaded from NPS Archive: Calhoun*

DUDLEY KNOX LIBRARY

Calhoun is the Naval Postgraduate School's public access digital repository for research materials and institutional publications created by the NPS community. Calhoun is named for Professor of Mathematics Guy K. Calhoun, NPS's first appointed -- and published -- scholarly author.

Dudley Knox Library / Naval Postgraduate School
411 Dyer Road / 1 University Circle
Monterey, California USA 93943

http://www.nps.edu/library

# THE DEVELOPMENT AND IMPLEMENTATION OF ALGORITHMS FOR AN A-7E PERFORMANCE CALCULATOR

Gary Lang Koger

# NAVAL POSTGRADUATE SCHOOL
## Monterey, California

# THESIS

The Development and Implementation
of Algorithms for an A-7E
Performance Calculator

by

Gary Lang Koger

September 1978

Thesis Advisor: R. Panholzer

Approved for public release; distribution unlimited

T185328

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
|---|---|---|
| 1. REPORT NUMBER | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle) The Development and Implemenation of Algorithms for an A-7E Performance Calculator | | 5. TYPE OF REPORT & PERIOD COVERED Master's Thesis; Sept 1978 |
| | | 6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s) Gary Lang Koger | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Postgraduate School Monterey CA 93940 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS |
| 11. CONTROLLING OFFICE NAME AND ADDRESS Naval Postgraduate School Monterey CA 93940 | | 12. REPORT DATE Sept 1978 |
| | | 13. NUMBER OF PAGES 157 |
| 14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) Naval Postgraduate School Monterey CA 93940 | | 15. SECURITY CLASS. (of this report) Unclassified |
| | | 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE |

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

In this thesis, the algorithms for an A-7E performance calculator were developed and then implemented on three small data processors of different programming levels and storage capabilities.

The utility of data is a function of several variables including accuracy and availability. The problem of retrieving performance data from the Naval Air Training and Operating Procedures Standardization (NATOPS) Manuals is significantly

DD FORM 1473 1 JAN 73 (Page 1) EDITION OF 1 NOV 65 IS OBSOLETE S/N 0102-014-6601 |

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

lessened by the devices demonstrated in this investigation. Nine performance chart groups, yielding the data usually considered necessary for flight, were reduced to a series of analytical expressions. These analytical expressions were demonstrated to reproduce NATOPS Manual data to a high degree of accuracy.

Implementation was demonstrated on a desk computer, a hand held calculator and a microprocessor.

Approved for public release; distribution unlimited

# The Development and Implementation of Algorithms for an A-7E Performance Calculator

by

Gary Lang Koger
Lieutenant, United States Navy
B.S. United States Naval Academy, 1971

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN AERONAUTICAL ENGINEERING

from the

NAVAL POSTGRADUATE SCHOOL
September 1978

Thesis
K735
c.

ABSTRACT

In this thesis, the algorithms for an A-7E aircraft performance calculator were developed and then implemented on three small data processors of different programming levels and storage capabilities.

The utility of data is a function of several variables including accuracy and availability. The problem of retrieving performance data from the Naval Air Training and Operating Procedures Standardization (NATOPS) Manuals is significantly lessened by the devices demonstrated in this investigation. Nine performance chart groups, yielding data usually considered necessary for flight, were reduced to a series of analytical expressions. These analytical expressions were demonstrated to reproduce NATOPS Manual data to a high degree of accuracy.

Implementation was demonstrated on a desk computer, a hand held calculator and a microprocessor.

TABLE OF CONTENTS

# LIST OF FIGURES

## ACKNOWLEDGEMENT

The author would like to thank Professor R. Panholzer for his advice and guidance throughout this investigation. The author is also indebted to LCDR C.D. Englehardt for suggestions and aid in the development of the microprocessor software.

For the original development concepts and enthusiasm for this investigation completion, LCDR W.M. Siegel is hereby acknowledged.

# I. INTRODUCTION

The Naval Air Training and Operating Standardization (NATOPS) Manual is the official standard of the United States Navy for "...information on all aircraft systems, performance data, and operating procedures required for safe and effective operations." [1]

The purpose of this thesis was to develop algorithms of the more often used NATOPS performance charts for the A-7E aircraft, examine their accuracy and implement them on small data processors that might be adaptable to shipboard or aircraft onboard use. The interpretation of NATOPS performance charts is an error prone and time consuming procedure even for experienced users. The need for a system to eliminate this laborious process has been fully documented in a thesis completed in June 1978 by LCDR W.M. Siegel [2]. In his investigation, LCDR Siegel devised an efficient procedure to develop algorithms from the NATOPS performance charts and exercised this procedure on the problems of "Takeoff Ground Roll Distance" and "Takeoff Airspeed".

This investigation is an extension of the aforementioned work. The original scope of this investigation was to develop algorithms for eleven of the most often used performance problem chart groups and implement them on the Texas Instruments-59 (TI-59) hand held calculator (HHC). All of the NATOPS performance charts were not reduced because of research time limitations. Of the eleven performance chart groups studied,

two performance problems, "Time to Climb" and "Fuel Required to Climb" were rejected because of implementation difficulties on the TI-59 HHC (discussed fully in "Development Difficulties"). Therefore, nine performance chart groups were reduced to analytical expressions and implemented on the TI-59 HHC. To show further possibilities and feasibility of implementation of the algorithms, they were 1) fully implemented on the Hewlett Packard-9830 (HP-9830) desk computer, 2) demonstrated on a microprocessor (INTEL Corporation Microcomputer System-48), and 3) considered for implementation on the A-7E onboard digital computer and a microprocessor utilizing a recently developed number processing chip by the National Semiconductor Corporation (MM57109).

# II. DEVELOPMENT

## A. GUIDELINES

The scope of this investigation was established after a firm set of guidelines was defined.

Being the official United States Navy standard for the A-7E aircraft, the A-7E NATOPS Manual was the sole source of performance data used to develop the algorithms. As such, and being subject to changes during the aircraft's life cycle, the need for possible future updates to the algorithms was acknowledged. The effective date of the NATOPS Manual from which these algorithms were developed is March 1975. Since the performance data yielded by the algorithms was identical to NATOPS Manual performance curves, the same restrictions and limitations apply. For example, takeoff airspeed calculation restricts the NATOPS Manual user to trailing edge flap positions between 20 and 40 degrees down (Figure 1). For that reason, one could not expect to calculate the flaps up takeoff airspeed using the developed algorithms. An additional feature provided by the algorithms was higher order interpolation. While the inexperienced NATOPS user might attempt to interpolate linearly between non-linearly spaced curves, the algorithms do not.

An important guideline for the user's benefit was to ensure the execution of these algorithms after implementation was simple enough so very little training was required for the users. Intended users were Naval Flight Officers and Aviators.

## TAKEOFF SPEED (A-7E)

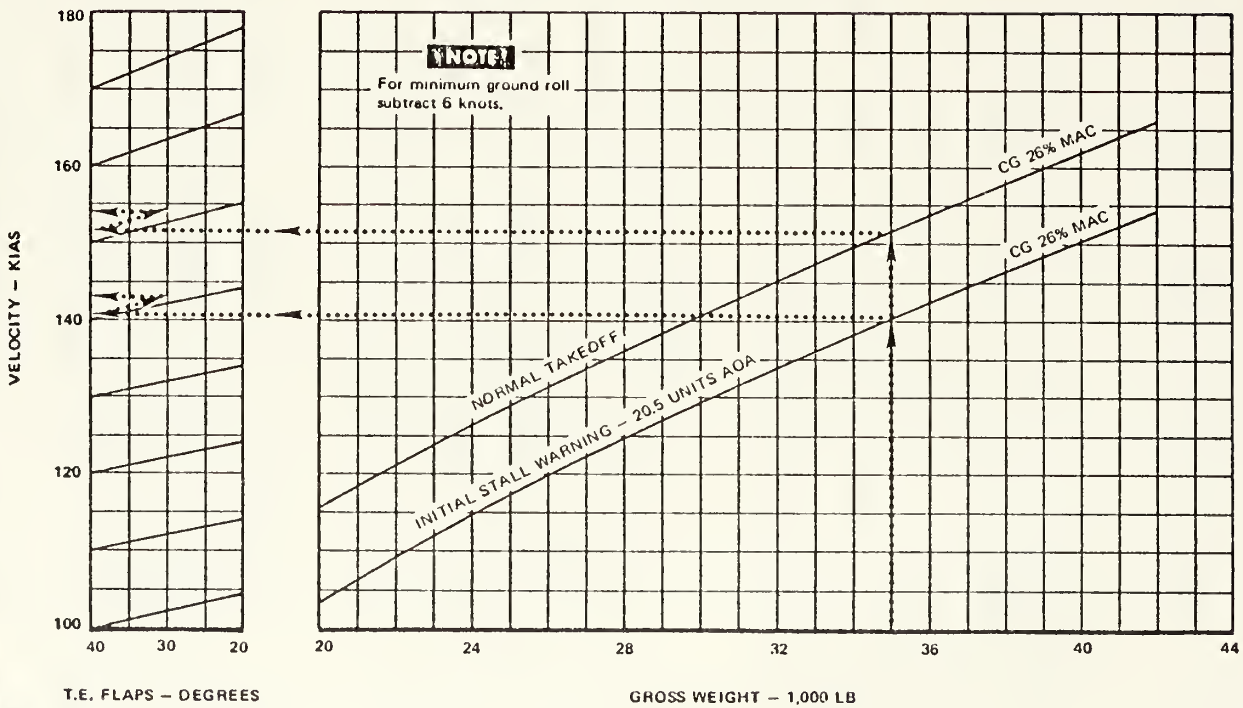
MODEL: A-7E
DATA BASIS: FLIGHT TEST
DATE: NOVEMBER 1971

CONDITIONS:
MILITARY RATED THRUST
LANDING CONFIGURATION
LEADING EDGE FLAPS DOWN

ENGINE: TF41-A-2
FUEL GRADE: JP-5
FUEL DENSITY: 6.8 LB/GAL

**NOTE**

Data basis is 26% MAC. Increase speed 1/2 knot per 1% forward CG shift. Decrease speed 1/2 knot per 1% aft CG shift.




76E254-02-72



Figure 1

Takeoff Speed NATOPS Chart

Not included in the scope of this thesis is an introduction to the TI-59 HHC, HP-9830 desk computer and the INTEL Microcomputer System-48; however, to follow the computer programs written for these devices would required their basic understanding.

Another guideline established was that the performance calculators be light and small enough to be physically suited for its environment. For example, the TI-59 calculator and microprocessor could be used in a cockpit, briefing room or Air Operations Center. The HP-9830 desk computer would be restricted from cockpit use.

Reliability was a necessary guideline.

To make algorithm implementation on the TI-59 HHC feasible and since the program storing chip, the Continuous Read Only Memory (CROM), was limited to 5000 calculator program steps, the library of nine programs was required to fit into that space [3].

Finally, accuracy was a necessary consideration. The results obtained from the algorithms were required to be at least as accurate as following the performance charts manually. These accuracy requirements established were: One knot of airspeed, 100 feet of altitude or ground roll distance, 100 pounds of weight, ten seconds of time and one nautical mile of distance.

## B. PERFORMANCE CHART REDUCTION

The reduction of the NATOPS Manual performance curves into analytical expressions was accomplished by a historically proven mathematical procedure, "least squares curve fitting". This method was applied to certain A-7E performance data by LCDR W.M. Siegel (see Introduction, Section I). His brief explanation of the "Least Squares Fit Approximation (LSFA)" is included in Appendix A.

Many performance charts from the NATOPS Manual contain three variables (two independent, one dependent) and are depicted as a two-dimensional space with the third dimension illustrated by a family of curves. The reduction of such a chart can be accomplished as follows:

1. Determine order of curves in family (i.e, second order, $(y = A_1 + A_2x + A_3x^2)$.

2. Apply LSFA to every member of the family of curves.

3. Since the order of the curve families may vary, a general curve family could be depicted as follows:

$$
\begin{array}{ll}
y = A_{11} + A_{12}x + A_{13}x^2 + \ldots\ldots A_{1m}x^{n-1} & (\text{for curve } z_1) \\
y = A_{21} + A_{22}x + A_{23}x^2 + \ldots\ldots A_{2n}x^{n-1} & (\text{for curve } z_2) \\
\vdots & \vdots \\
y = A_{m1} + A_{m2}x + A_{m3}x^2 + \ldots\ldots A_{mn}x^{n-1} & (\text{for curve } z_m)
\end{array}
$$

4. Apply LSFA to the coefficients. For example, plot $A_{11}$, $A_{21}, \ldots\ldots A_{m1}$ versus $z_1, z_2, \ldots\ldots z_m$, respectively, yielding

$$A_1 = B_{11} + B_{12}z + B_{13}z^2 + \ldots\ldots B_{1r}z^{r-1}.$$

Doing the same with all coefficients,

$$A_2 = B_{21} + B_{22}z + B_{23}z^2 + \ldots B_{2r}z^{r-1}$$
$$\vdots \quad \vdots \quad \vdots \quad \vdots \quad \vdots$$
$$A_n = B_{m1} + B_{m2}z + B_{m3}z^2 + \ldots B_{mr}z^{r-1}$$

5. Given z and x, y can now be calculated by:

a. Computing coefficients from equations generated in Step 4.

b. Applying coefficients to $y = A_1 + A_2x + \ldots A_nx^{n-1}$.

6. It is important to note that although all curve family members must be of identical order, the equations representing the coefficients as a function of "z" need not be of similar order.

Although applying LSFA to the family of curves and then to their coefficients was the normal method of chart reduction, it was not always used for the following reasons:

a. Some charts were two-dimensional (LSFA still used).

b. Some charts were reduced by inspection.

(1) Linear curve families with linear spacing.

(2) Time, distance, speed charts ($d = v/t$).

c. Algorithm anomalies (see "Development Difficulties").

When used, the LSFA was accomplished by a program pre-written by the Hewlett Packard Corporation for use with the HP-9830. This program, although greatly facilitating the development portion of this investigation, was written for a two-dimensional problem and had to be executed at least once for each curve and once for each set of coefficients.

A listing of all of the equations making up the performance algorithms are contained in Appendix C. The A-7E

performance chart groups from which they were developed are contained in Appendix B. They are in order:

1. Low Level Cruise Performance.
2. Takeoff Ground Roll Distance.
3. Maximum Range Cruise Time and Speed at Constant Altitude.
4. Maximum Range Cruise Fuel Required at Constant Altitude.
5. Maximum Range Climb Airspeed Schedule.
6. Takeoff Airspeed.
7. Maximum Refusal Airspeed.
8. Optimum Endurance Altitude.
9. Cruise Ceiling.

Future reference in this thesis is made to algorithms and programs by the numbers above.

## C. EXAMPLE OF CHART REDUCTION

An example of the procedure discussed in the previous section is presented below. The chart chosen for reduction is the lower graph of Figure 2, from Phase II of the A-7E Cruise Performance chart group.

By inspection, all $A_1$ and $A_2$ coefficients are equal to zero. The curves appear parabolic and therefore second order, yielding $N = A_3M^2$. The example follows:

N = intermediate result

M = mach number

D = drag count

# CRUISE PERFORMANCE (A-7E)

11–117

## PHASE II – AIRCRAFT REFERENCE NUMBER

MODEL: A-7E
DATA BASIS: FLIGHT TEST
DATE: NOVEMBER 1971

ENGINE: TF41-A-2
FUEL GRADE: JP-5
FUEL DENSITY: 6.8 LB/GAL

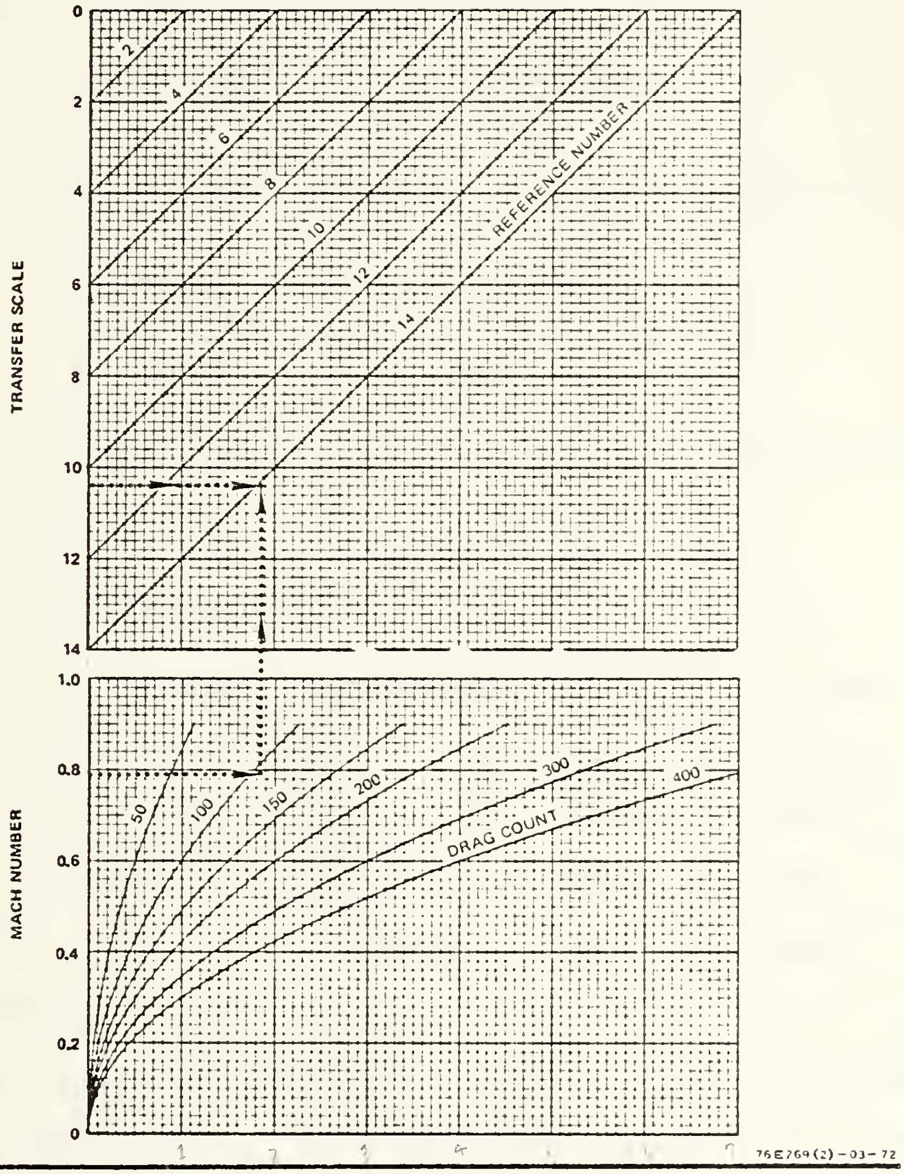





Figure 2

Cruise Performance
Phase II NATOPS Chart

| DRAG COUNT LINE | CURVE EQUATION |
|---|---|
| 50 | $N = 1.3915M^2$ |
| 100 | $N = 2.7787M^2$ |
| 150 | $N = 4.1658M^2$ |
| 200 | $N = 5.5530M^2$ |
| 300 | $N = 8.3273M^2$ |
| 400 | $N = 11.102M^2$ |

By plotting the $A_3$ coefficients versus D (drag count), the LSFA yields:

$$A_3 = (4.3732E-3) + .027743D$$ and therefore,

$$N = ((4.3732E-3) + (.027743D)M^2.$$

This was a particularly simple chart to reduce but illustrates the procedure.

## D. DEVELOPMENT DIFFICULTIES

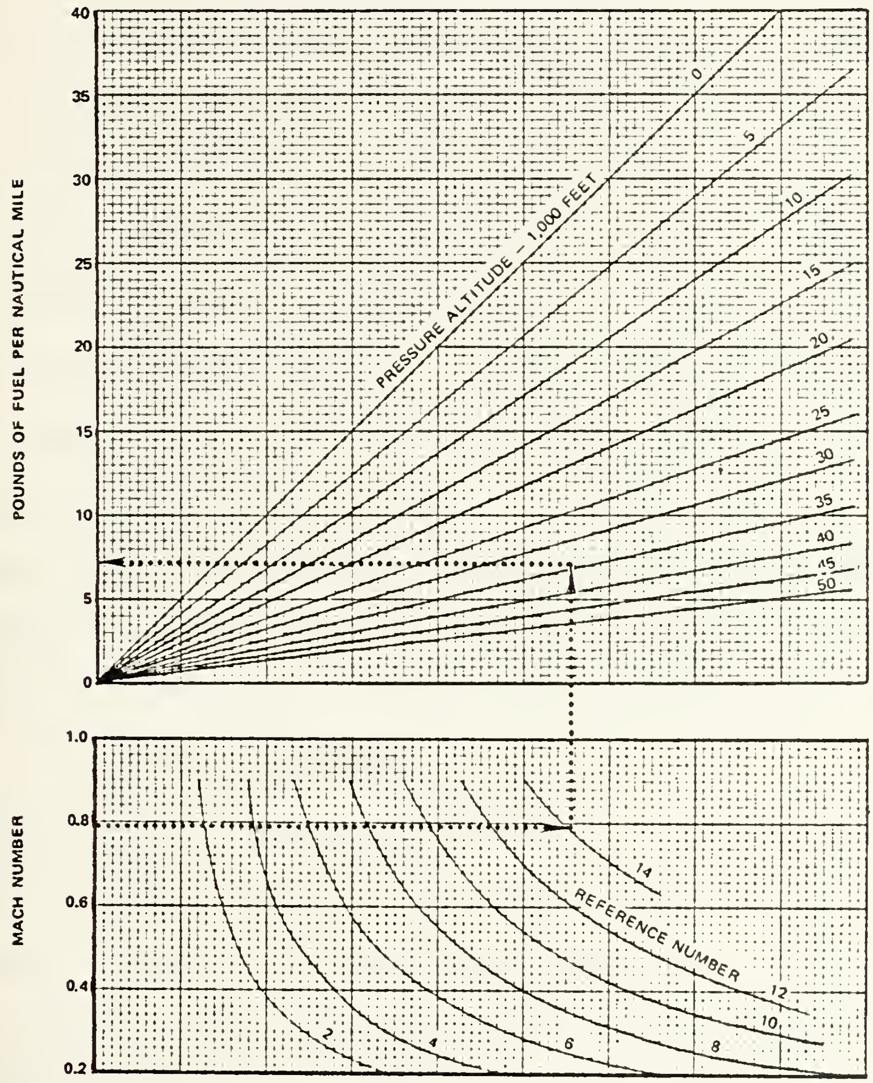
The normal method of reducing performance curves did not always yield useful information. One reason was although the NATOPS Manual Performance curves were constructed from experimental data, families of curves occasionally had very unusual spacing. They also were not always a true curve family; that is, they were of varying order. This can be visually detected in the lower graph of Phase III of the A-7E Cruise Performance chart group (Figure 3). The unequal and varying spacing between curves with different "reference numbers" is obvious. Although the coefficients for each curve can be calculated, the coefficients determined for a LSFA equation for an intermediate curve would be incorrect. To be usable for the normal

## CRUISE PERFORMANCE (A-7E)

PHASE III – POUNDS OF FUEL PER NAUTICAL MILE

MODEL: A-7E
DATA BASIS: FLIGHT TEST
DATE: NOVEMBER 1971

ENGINE: TF41-A-2
FUEL GRADE: JP-5
FUEL DENSITY: 6.8 LB/GAL




76E769(3)-03-72



Figure 3

Cruise Performance
Phase III NATOPS Chart

method of chart reduction, a chart must have equal, constantly increasing, or constantly decreasing spacing between curves. When such an incompatible chart was encountered, it was necessary to interpolate between them. Two chart groups eliminated from consideration, "Fuel Required" and "Time to Climb from Sea Level to Selected Altitude", contained so many such curves (11), that very high order expressions would have been required to compute the coefficients, making implementation on the TI-59 HHC impractical. The A-7E Cruise Performance lower chart of Phase I had the same anomaly (Figure 4). Because of the importance of the low level mission, however, the algorithm for this chart was developed, for sea level only though. The multiple algorithm was not developed but could have been for implementation on a desk computer.

Another reason a straight application of LSFA was not always appropriate was the uniqueness of the upper graph of Phase I of the A-7E Cruise Performance chart group (Figure 4). This chart requires entry from the lower chart. A line is traced upward until the user contacts the appropriate Drag Count Line (dotted lines). The first pass through the Mach Number axis, a result of the lower chart, was defined M*. Instead of now tracing horizontally to the Transfer Scale axis (this value defined TS*), one must trace "between the solid guidelines" to the interception with a line traced vertically upward from the desired Mach number, M. The Transfer Scale would now be manually obtained by tracing horizontally to the

## CRUISE PERFORMANCE (A-7E)

### PHASE I – CLEAN AIRPLANE TRANSFER SCALE

MODEL: A-7E
DATA BASIS: FLIGHT TEST
DATE: NOVEMBER 1971

ENGINE: TF41-A-2
FUEL GRADE: JP-5
FUEL DENSITY: 6.8 LB/GAL

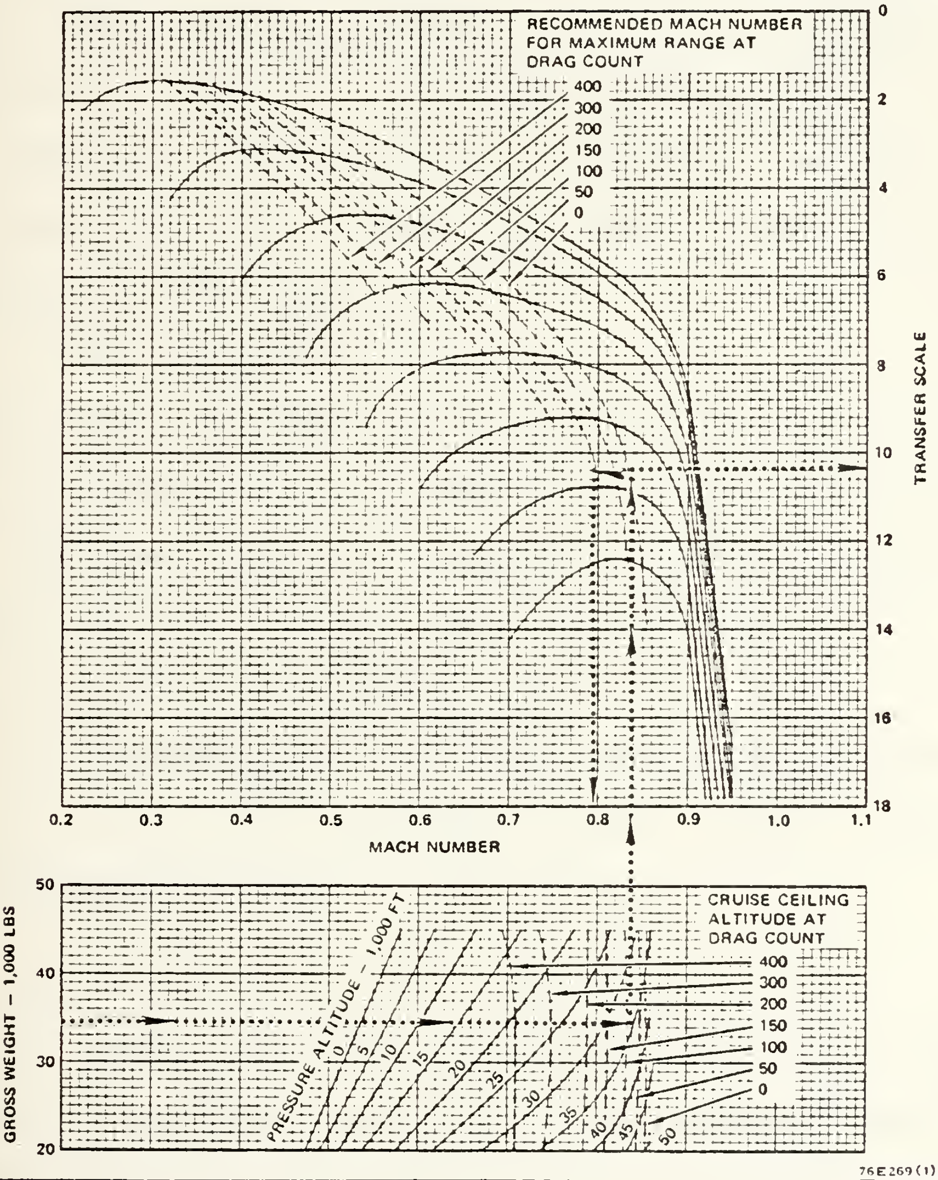



Figure 4



Cruise Performance
Phase I NATOPS Chart

vertical axis. To develop the algorithm for this problem, the equations of the guidelines were also calculated as a function of Mach number. The values of the Transfer Scale resulting from M* intercepting the guidelines and tracing horizontally to the vertical axis were called $TS_1^*$, $TS_2^*$, $\ldots TS_m^*$, from top to bottom. The original position, (M*, TS*), could now be determined in relation to (M*, $TS_n^*$) and (M*, $TS_{n+1}^*$). "n" and "n+1" indicate the upper and lower guidelines, respectively, which bracket (M*, TS*). This ratio provided the initial position relative to the guidelines:

$$R = (TS^*-TS_{n+1}^*)/(TS_n^*-TS_{n+1}^*)$$

Using the desired Mach number, M, the Transfer Scales for the same two enclosing guidelines were calculated ($TS_n$ and $TS_{n+1}$). The final position relative to the guidelines was maintained using the original ratio by solving:

$$R = (x-TS_{n+1})/(TS_n-TS_{n+1}) \text{ for } x.$$

"x" is the Transfer Scale with which the user now proceeds to Phase III of this performance chart group. Figure 5 depicts this problem graphically.

## E. ACCURACY

A large number of results comparisons between the generated algorithms and manually traced performance problems were made. An infinite number of comparisons would be required to check all possibilities, but since the mathematical theory was so basic, the number of checks accomplished were considered sufficient.

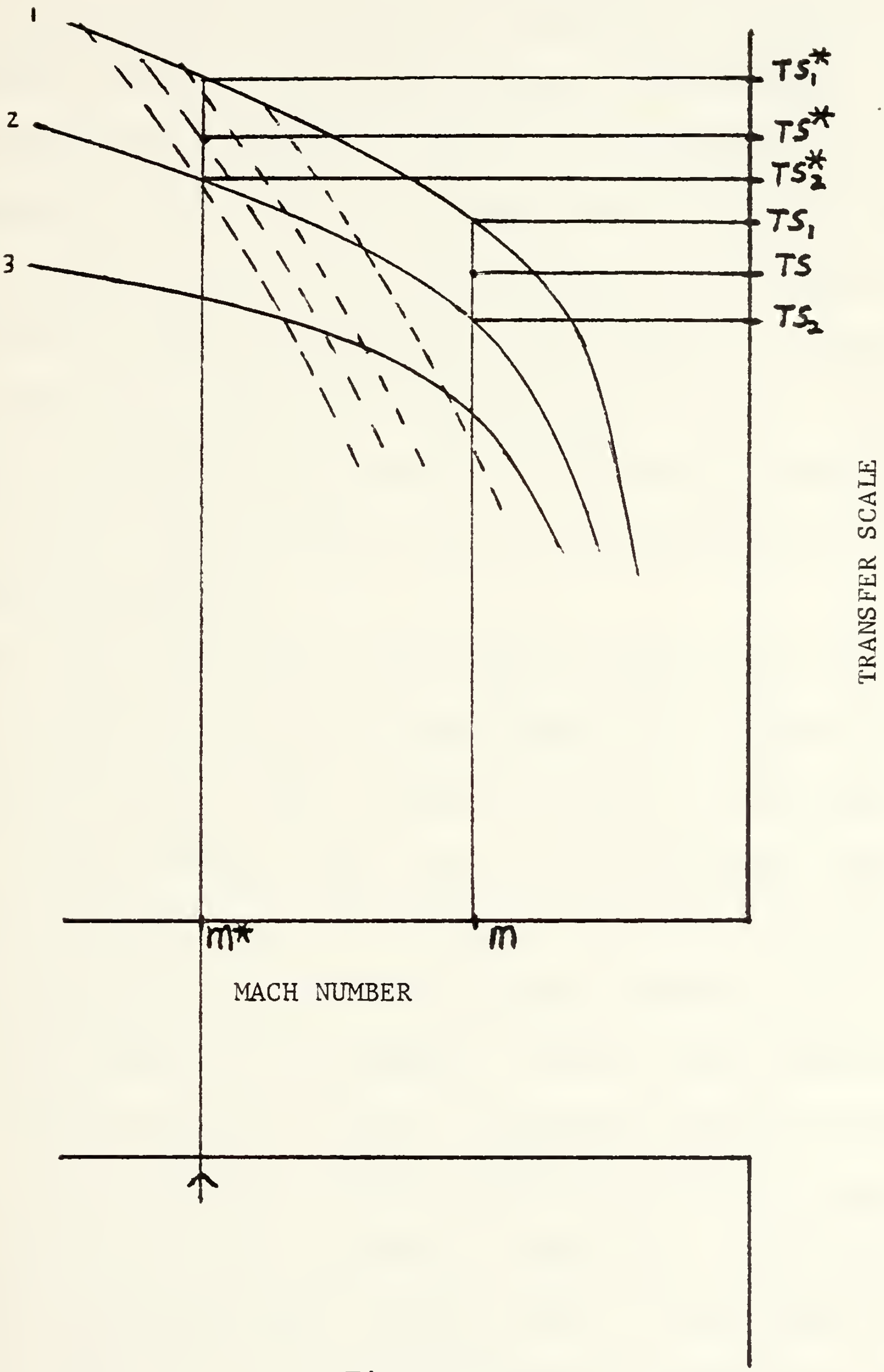



Figure 5

Guideline Chart Solution

All nine algorithms were checked for accuracy on the HP-9830 desk computer. The number of checks for each algorithm was proportional to the ease of manually tracing through the performance charts. The author spent considerable time obtaining performance results from the NATOPS Manual charts and a relatively small amount of time computing the problems on the desk computer once the algorithms had been implemented. In a significant number of instances, the results disagreed, but after rechecking, the solution obtained manually was in error. This supported the contention that manual manipulation of the performance charts is an error prone procedure, even with an experienced user.

In a few rare instances, the author entered the required given data incorrectly into the desk computer. These miskeying errors, not procedural, were noticed as soon as the answer was produced. A user familiar with the A-7E performance characteristics would normally notice an answer resulting from grossly incorrect data input. It is acknowledged, however, that there is no failsafe check on the programs. When using a desk computer, the required input data can be printed along with the answer to ensure the user of the correctness of the input data. For a hand held calculator, however, computing a performance problem twice would provide a check, which is what many NATOPS Manual users often do. As with all computer programs, a desired result requires accurate input data.

Except for those noted below, the results of programs checked (using five significant figures) were indistinguishable from the answers obtained by manually manipulating the performance charts. Answers produced from the algorithms were rounded off to the nearest digit.

| PROGRAM | MAXIMUM DEVIATION |
| --- | --- |
| Maximum Refusal Speed | 2 knots |
| Takeoff Airspeed | 1 knot |

# III. IMPLEMENTATION

## A. DESK COMPUTER

The use of a desk computer capable of producing A-7E performance information within seconds (less than three seconds computation time for the longest algorithm) would be ideal for a squadron briefing room or Air Operations Center use. The HP-9830 desk computer was used for this implementation stage. Very little training would be required for personnel to load the programs stored on a cassette tape cartridge and execute them.

A knowledge of "basic" computer language is required to fully understand the nine HP-9830 programs in Appendix D [4]. The nine programs are in the same order as the algorithms of Appendix C.

Only in the Low Level Cruise Performance program are subroutines required for linear interpolation or for the iterative method to find the Transfer Scale (see "Development Difficulties"). All other programs are straight forward, sequential computations. In these programs, the coefficients defining a curve (y = f(x)) for a given set of conditions are calculated. That chart result, "y", is then calculated for the given independent variable "x". The next chart of that group is similarly treated and so on until the "final result" is achieved.

The HP-9830 programs are very useful since they prompt the user to supply the correct information. Most of the programs

"request, then accept" those inputs required for the applicable NATOPS Manual performance chart. The HP-9830 then prints the data just entered (ensuring the user that data input was as desired) followed quickly by the solution. The computer is instantly ready to receive new data for another calculation.

Programs 1, 2, 3, 4 and 7 (as identified in "Performance Chart Reduction, section II-B), are written in this "request, then accept" format. The shorter programs, 5, 6, 8 and 9, were written with an initial set of input data already in the program. This format allowed the computer to step incrementally through the allowable range of values for the input data, thus calculating a "table of performance data" for the applicable performance chart group. These programs are easily altered to the "request, then accept" format by some simple edit commands [4].

The variables used in the programs are defined following each program in Appendix D.

## B. HAND HELD CALCULATOR

The many favorable features of the hand held calculator encouraged its implementation of the performance algorithms. Its small size allowed consideration for use in the cockpit. Its simplicity and reliability was an advantage making it especially suited for users of varying experience (including no experience). Although its execution speed was the slowest of all devices used, the computation time was still much faster than using the NATOPS Manual.

The Texas Instruments-59 (TI-59) programmable hand held calculator (HHC) was selected for implementation. This selection was made for several reasons. At the time, it was the only calculator available to the author which allowed permanent program storage (on magnetic cards). Additionally, the Texas Instruments Corporation had the capability to combine all pre-written performance programs, up to a 5000 program step limit, onto a Continuous Read Only Memory (CROM) chip, making the A-7E performance programs a permanent part of the calculator. This CROM chip can also be used on the less expensive TI-58 HHC. These features made the TI-58/59 (with CROM) a practical system for the A-7E Naval Aviation community.

One might consider the calculator's inability to prompt the user for inputs a shortcoming of this implementation candidate, but a company spokesman, Mr. Richard Cuthbert, stated a new face could be fitted onto the calculator, identifying different buttons with the input data categories such as GW for gross weight, FLPS for flap position, T(°C) for temperature, and so on [3].

Some time was required for the author familiarization with the TI-59 HHC and its capabilities. For a detailed explanation of comments in this section involving TI-59 programming and Appendix E, consult the user's manual [5].

All programs were entered with the calculator memory partitioned to allow 879 program steps and ten memory storage locations. The loss of program steps in order to provide coefficient storage locations (ten to one) was the reason for

partitioning in this manner. Only five significant figures were considered necessary for computational accuracy. Considering the number possibilities (1.2345 to 1.2345E-12) might take from six to ten program steps, this was less than the absolute ten program steps sacrificed for a storage location. The ten memory storage locations were used to store the input data at program execution start but were often reused after the input data storage was no longer required.

The programming language level of the TI-59 HHC is below the HP-9830's and above a microprocessor's (discussed later) in sophistication. The algorithms were computed in a more space-saving manner than on the HP-9830. For example, in computing a first order polynomial, the HP-9830 program functioned as follows:

$$B(0) = A_{11} + A_{12}z$$

$$B(1) = A_{21} + A_{22}z$$

$$y = B(0) + B(1)x.$$

The TI-59 HHC was programmed to compute as follows:

$$(A_{11} + A_{12}z) + (A_{21} + A_{22}z)x = y.$$

In the Low Level Cruise Performance program, the linear interpolation and iterative methods to follow guidelines (discussed in previous section) was still accomplished using the more tedious TI-59 HHC language.

Using the partitioning already described, a program limit of 879 program steps was imposed (filling two magnetic cards). Two programs, "Takeoff Ground Roll Distance" and "Low Level

Cruise Performance", exceeded this limit and had to be continued on extra cards. These programs were written to allow storage of an intermediate result into the T-register. The rest of the cards could then be read in, any lost or newly acquired input data entered, and program execution would continue, automatically retrieving the stored intermediate result from the T-register. These artificial necessities for program completion using the magnetic cards would not be necessary if the programs were stored permanently in the CROM.

The total number of steps required for the nine performance algorithms programmed on the TI-59 HHC was 5461 steps. By subroutining (340 steps of programming are common to two programs), the total number could be reduced to 5121 steps. The elimination of the artificial steps required for the oversized programs would reduce the overage more. The sole intent of this implementation phase was not to fit these nine programs into the 5000 step CROM. If the inclusion of all nine programs was desired, streamlining aid offered by engineers from the Texas Instruments Corporation plus the reduction of significant figures in a non-critical area would accomplish this.

The program listings, storage location usage, user instructions, and execution times are included in Appendix E.

## C. MICROPROCESSOR

### 1. Single Board Computer using Software for Mathematical Operations

The single board computer (SBC) implementation was investigated both as an extension of thesis work and to meet

the course objectives of AE-4900, Air Data Systems. Work toward this effort was also done by LCDR W.M. Siegel. The performance algorithms were to be processed on a SBC using an INTEL Corporation 8048 Programmable Read Only Memory (PROM), external random access memory (RAM) and a program counter. Software development was completed on the INTEL Prompt-48 (Microcomputer System-48 language) using an INTEL 8035 arithmetic logic unit (ALU). Although a SBC using the 8048 PROM and requiring a digital keyboard and display was never actually constructed because of the time limitations, the software operation was successfully demonstrated on the Prompt-48.

To preserve the programs between operation periods, the Prompt 48 was hand wired as specified in the user's manual to an ASR-35 Teletype set which allowed paper tape storage [6]. The Prompt-48 provided 1024 by two bytes of RAM and 64 by two bytes of resident memory. Although the MCS-48 instruction set will not be discussed in this thesis, a basic understanding of assembly level language is necessary to understand the developed software presented in Appendix F [7]. This microprocessor program listing includes the MCS-48 instructions in hex code and literal mneumonics and includes full documentation to facilitate interpretation.

A full performance algorithm was not implemented on the Prompt-48 because of its memory storage limitations. The original intent was to exercise the software of the complete A-7E Takeoff Ground Roll Distance algorithm on the Prompt-48.

After the necessary routines were written and stored, only room for three coefficients remained (98 coefficients required for this algorithm). Since implementation capability was the desired result, the computation of a second order polynomial was considered sufficient. Although this effort was software oriented, the necessary RAM storage for the additional coefficients and executive routine could have been easily provided for a SBC.

The software development for algorithm implementation required routines for input/output (I/O), executive direction, binary to binary coded decimal (BCD) and BCD to binary conversions, and floating point binary addition and multiplication routines. The I/O and executive routines were written by LCDR Siegel. The nonavailability of a number oriented microprocessor at the time of this effort required the development of the mathematical package described above. The advantages for such a capability will be discussed in the following section.

In addition to the microprocessor software developed by the author and LCDR Siegel, the I/O and display routines would require alteration for SBC implementation since a digital display and keyboard would replace the Prompt-48.

Figure 6 illustrates the solution method. Figure 7 is a flow chart of the program execution sequence. Figures 8 and 9 show the Prompt-48 RAM and resident register memory, respectively.

SBC SOLUTION METHOD

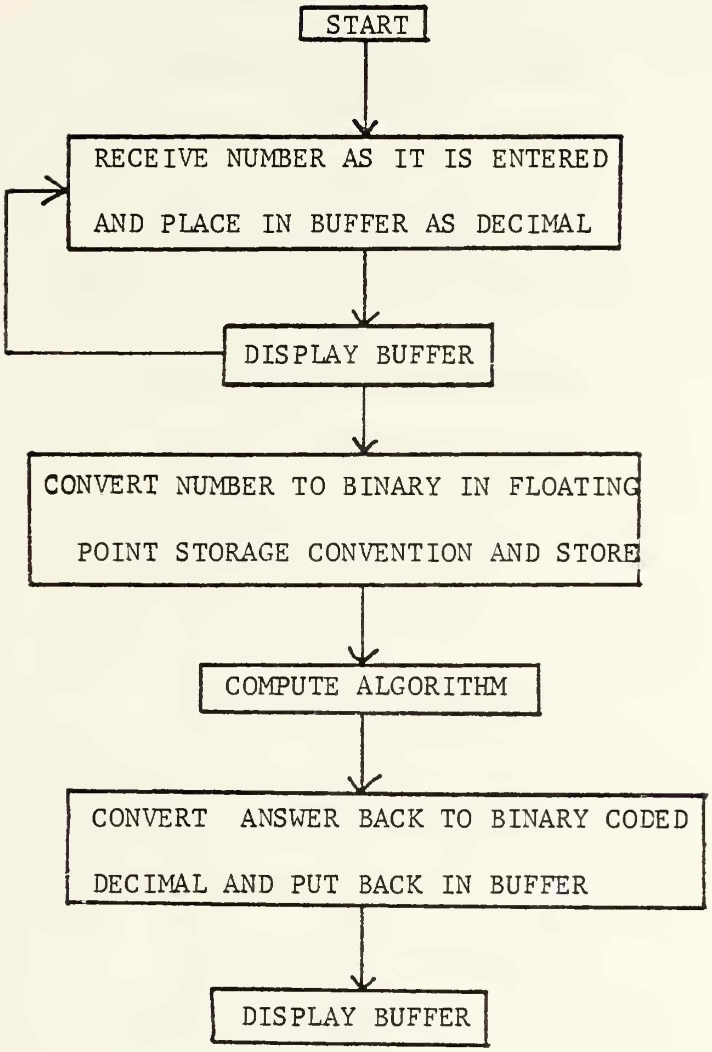



Figure 6

SBC Solution Method

SBC PROGRAM EXECUTION SEQUENCE

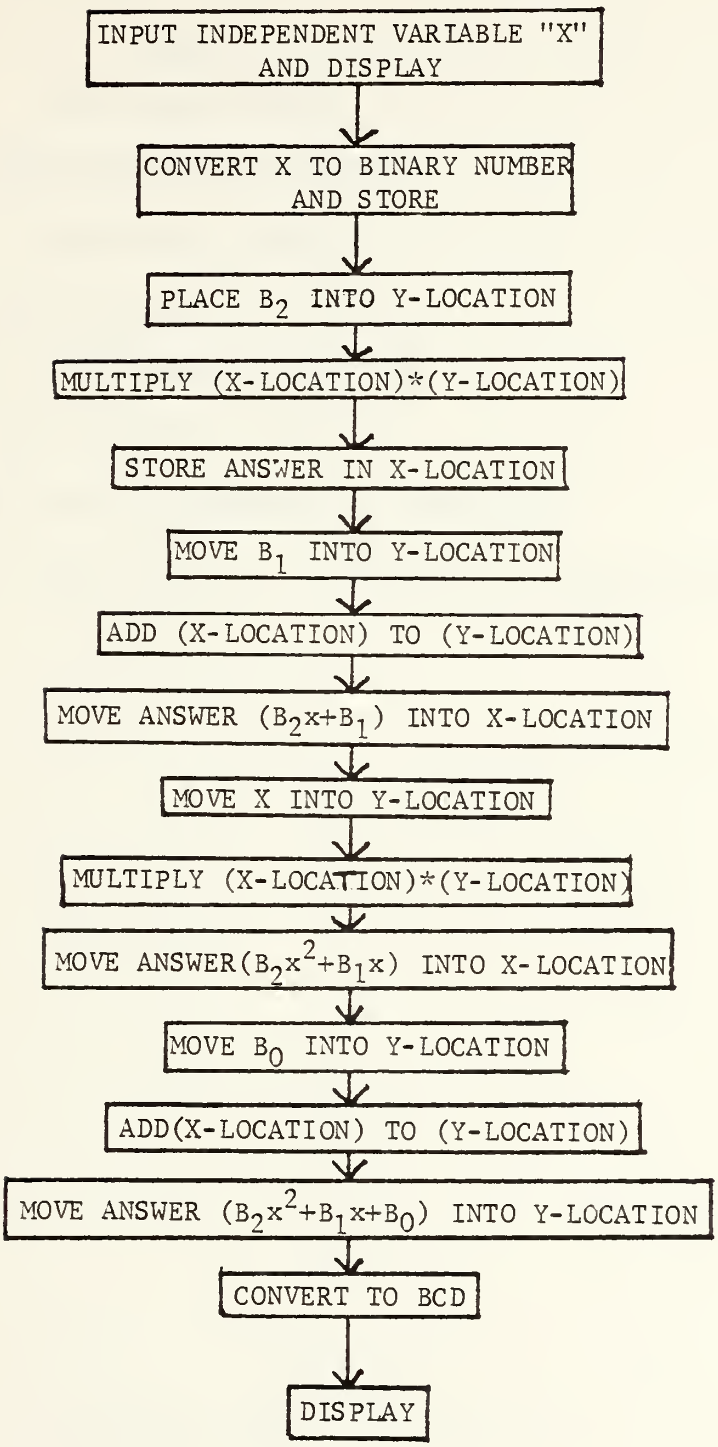



Figure 7

SBC Program Execution Sequence

## RANDOM ACCESS MEMORY MAP

| ADDRESS | USE |
| --- | --- |
| 000-069 | INPUT AND DISPLAY |
| 06A-06F | EXECUTIVE ROUTINE SEGMENT |
| 070-079 | COEFFICIENT STORAGE |
| 07A-0C6 | MAIN EXECUTIVE ROUTINE |
| 0C8-0E2 | BINARY TO BCD EXECUTIVE ROUTINE |
| 0E5-0FF | MISCELLANEOUS SUBROUTINES |
| 100-2EC | ADDITION AND MULTIPLICATION SUBROUTINES |
| 300-3FF | BCD TO BINARY EXECUTIVE ROUTINE AND CONVERSION SUBROUTINES |

Figure 8

Random Access Memory Map

RESIDENT REGISTER MAP

| ADDRESS | USE | ADDRESS | USE |
|---|---|---|---|
| 20 | LSB | 30 | |
| 21 | X-LOCATION | 31 | |
| 22 | ARITHMETIC REGISTER | 32 | LSB |
| 23 | MSB | 33 | DISPLAY HEX |
| 24 | EXPONENT | 34 | BUFFER |
| 25 | LSB Y-LOCATION | 35 | MSB |
| 26 | MSB ARITHMETIC REGISTER | 36 | DECIMAL POINT MASK |
| 27 | EXPONENT | 37 | CHARACTER COUNTER |
| 28 | LSB BCD-BINARY | 38 | LSB |
| 29 | MSB CONVERSION | 39 | |
| 2A | EXPONENT | 3A | DISPLAY |
| 2B | | 3B | |
| 2C | | 3C | BIT |
| 2D | | 3D | |
| 2E | | 3E | PATTERNS |
| 2F | | 3F | MSB |

Figure 9

Resident Register Map

The second order polynomial, $y = B(0) + B(1)x + B(2)x^2$, was calculated using a mathematical executive routine (alterable for any size polynomial and any number of polynomials). The only mathematical operations required were multiplication and addition of positive or negative numbers. For speed, binary arithmetic was used. For increased storage capability and mathematical efficiency, a floating point capability was included.

The calculation routine proceeded as follows:

$B_2 * x = (B_2 x)$

$(B_2 x) + (B_1) = (B_2 x + B_1)$

$(B_2 x + B_1) * x = (B_2 x^2 + B_1 x)$

$(B_2 x^2 + B_1 x) + B_0 = (B_2 x^2 + B_1 x + B_0)$

Although all mathematical operations are performed in the 8-bit (2-byte) accumulator register of the 8035 ALU (for a SBC, the 8048 PROM), a working accumulator using five registers (resident memory registers two through six), was established. All numbers in the program (independent variable "x" after conversion to binary, coefficients stored in RAM 070-079 and the 'result') were in one of two binary conventions. While in storage, the numbers were in "storage" convention. The numbers were shifted from "storage" to "working" convention only when transferred from the X and Y locations (see resident register memory map, Figure 9) to the working accumulator (registers two through six). When the desired operation was completed, the result was returned to the "storage" convention

and moved to the "X" location. Figure 10 displays the "storage and working" conventions.

This software was successfully demonstrated on the Prompt-48. The user instructions for the Prompt-48 to repeat the demonstration are listed below:

(1) Ensure the 8035 ALU or 8048 PROM is inserted in the "execution" socket of the Prompt-48.

(2) Enter the program in hex code in the proper storage locations as listed in Appendix F.

On the Prompt-48, press the following keys to clear the resident register memory:

"C"

"Registers"

"0"

","

"4"

"8"

Do not press "Program Memory" instead of "registers" or the program just entered will be erased.

(3) To execute the program, press the following keys:

"A"

"2"

"Execute"

"Go"

"No Break"

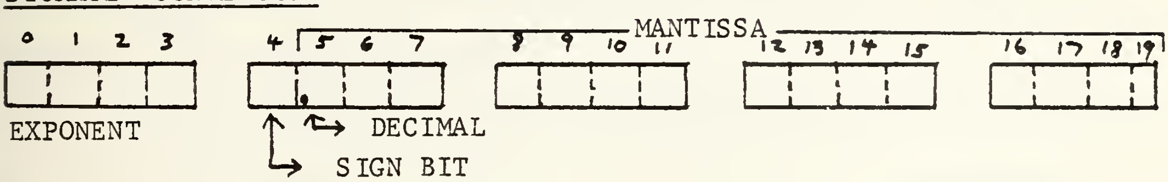
"0"

"Execute"

## BINARY CONVENTIONS

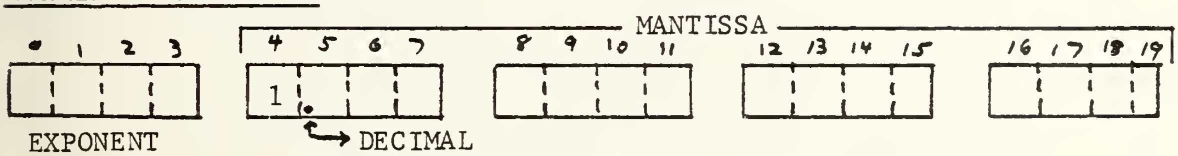
Each large block depicts 1 byte which includes 4 bits. The compartmented blocks represent 1 bit.

STORAGE CONVENTION




In storage convention, the mantissa is left justified to bit 5. A positive number is denoted by 0 in the first bit of the second byte(sign bit); a 1 indicates a negative number.

WORKING CONVENTION




In working convention, the mantissa is left justified to bit 4. The sign bit is stored in F0(X-location number) and F1(Y-location number) flags of the program status word.

Figure 10

Binary Conventions

The display will blank, awaiting the input of the independent variable "x". To enter "x", enter the digit keys for numbers (base 10) and "D" for decimal point. "x" will be displayed on the digital display as it is entered. To compute the algorithm (second order polynomial), press "E". The answer will rapidly appear. To calculate the polynomial with a new value for "x", start at Step 3.

(4) To prevent the time consuming reloading of the program, it is advisable to store the program on a peripheral device (paper tape, disc, etc.).

2. <u>Single Board Computer using Number Oriented Microprocessor</u>

Very recently, the National Semiconductor Corporation began production of a chip intended for use in number processing applications [8]. This chip, the MM57109 MOS/LSI, is capable of all scientific calculator functions, test and branch capabilities, internal number storage, and I/O instructions. Of the specific calculator functions, only addition, subtraction and multiplication would be used.

A SBC using this chip would need the 8048 PROM for coefficient and executive routine storage but would not need the space consuming mathematical package of the SBC in the last section. A program counter would still be required but external RAM would not. The computation time would be increased over the demonstrated SBC (approximate computation time of a HHC), but the simplicity of programming would make this proposed SBC very attractive.

## D. A-7E TACTICAL COMPUTER

In February 1978 the author made a trip to the Naval Air Facility at China Lake, California. The purpose of this visit was to receive indoctrination on the TC-2/2A tactical computers and obtain a programming manual for these devices. The desired goal was implementation of selected performance algorithms on the laboratory bench computer run by the A-7 Program Office of the Naval Weapons Center (NWC). A thorough understanding of the computer's capabilities and limitations was provided by Mr. Robert Westbrook, a software technician.

The A-7E computer provides very accurate navigation and weapons guidance capability. The TC-2 and TC-2A computers are a generation apart, the TC-2A being over two times faster and having twice the storage capability of its earlier version. Both computers are operational at this time. Specific design and programming information is available from the programming manual [9].

The instruction set of the tactical computer provides fixed point arithmetic, logical transfer of control (branching), address modification and single word input/output instructions specifically intended for operations primarily involving arithmetic. These features made the implementation of algorithms a logical decision. Several factors made this implementation by the author impractical. The computer design was quite old, the instruction set being very tedious and difficult to interpret. The computer's inability to function using floating point

arithmetic would require a significant software effort in that area alone. The time required to become fully familiar with the instruction set, write the software, and load and test the programs at NWC would have been prohibitive for this investigation.

It is hoped that the programmers at NWC will be able to implement those algorithms deemed desireable to achieve an onboard capability. Takeoff Airspeed and Maximum Refusal Airspeed are considered ideal for implementation.

## IV. CONCLUSIONS AND RECOMMENDATIONS

Nine of the A-7E NATOPS Manual performance chart groups were reduced to a series of analytical expressions or algorithms. These algorithms, accurate to five significant figures, are as accurate as results obtained by manual manipulation of the performance charts.

Implementation was made on three data processors of different programming levels and storage capabilities. These devices and degrees of implementation were:

(1) HP-9830 Desk Computer - complete implementation with successful demonstration.

(2) TI-59 Hand Held Calculator - complete implementation with successful demonstration.

(3) Microprocessor - partial implementation with successful demonstration.

In view of the success of this investigation, recommendations concerning implementation possibilities are listed below:

(1) Complete reduction of the NATOPS Manual performance charts could be accomplished and implemented onto a desk computer as one large program capable of performance data computation within seconds. The desk computer would be ideal for mission planning on a squadron or air wing level or for Air Operations Center use.

(2) The programs written for the TI-59 HHC could be consolidated onto a CROM and used with a TI-58 HHC for use on a

squadron level. As an alternative, the software could be rewritten for any HHC of comparable capability.

(3) Although implementation on a single board computer using a number oriented microprocessor is completely feasible, because of programming ease and cost consideration, the HHC is considered a superior implementation possibility at this time.

(4) The A-7E tactical computer could easily be programmed by software engineers at NWC, China Lake, California, to produce an onboard capability.

## APPENDIX A

### Least Squares Fit Approximation

References 10 and 11 describe the Least Squares Fit Approximation in detail. In general the problem is to represent a set of "n" data points in two-dimensional space

$X_i, Y_i \quad i = 1 \text{ to } n$

by a polynomial expression of a curve whose degree is less than "n". Two classes of problems exist:

(1) Linearly independent - those in which the degree (d) of the polynomial is one less than the number of data points

$$d = n-1 \tag{1}$$

(2) Linearly dependent - those in which the degree (d) is less than n-1

$$d < n-1 \tag{2}$$

As an example, a set of four (4) data points randomly spaced was chosen. If a third degree polynomial of the form

$$Y = A + BX + CX^2 + DX^3 \tag{3}$$

were desired, and the data points $X_i$ and $Y_i$ were inserted ($i = 1$ to 4) into four such equations, an exact solution for the four unknown coefficients would exist. These four unknowns could be found from the four equations by numerous conventional techniques (Direct substitution, Cramer's rule, etc.). The polynomial expression generated would be termed a "col-location" polynomial because its plot would pass through all data points.

It is often advantageous to describe a set of data points by a curve that does not pass through each point. This type of polynomial would be termed a "regression" equation. For any set of data points an infinite number of regression expressions exist for any specified degree (except the linearly independent case) and the object of the Least Squares Method is to find the polynomial coefficients of the chosen degree that best describe the data points. In the previous example of four data points, assume that, instead of the third degree form chosen, a second degree equation were selected of the form

$$Y = A + BX + CX^2 \tag{4}$$

With four data points, the polynomial is overspecified and thus linearly dependent. For this case an infinite number of solutions exist for the coefficients a, b and c. If an error term ($\delta$) were defined for any given X,Y pair as

$$\delta_1 = |Y_1 - A + BX_1 + CX_1{}^2| \tag{5}$$

a total squared error term (E) could then be defined by squaring and summing the terms attained:

$$E = \sum_{i=1}^{N} \delta_1{}^2 \tag{6}$$

If E were them minimized for any given degree chosen, the best Least Squares Fit would have been achieved.

If the values for $\delta$ from Equation 5 were inserted in Equation 6 and the partial derivative of E were taken with respect to the coefficient A, an equation would be generated that when set equal to zero (0) would define a minimum value of E for a given value of A. If the same operation were performed with respect to the

coefficients B and C then three equations would be generated with three unknowns (A, B and C). The solution of these simultaneous equations would produce the coefficients A, B and C, that would minimize the value of E and hence would produce a Least Squares Fit approximation to a set of linearly dependent equations.

A numerical procedure has been developed to accomplish this task. An example of this procedure has been included in the following paragraphs [10, 11].

Least Squares Fit Method Example

Given the following set of data:

| | | | | | |
|---|---|---|---|---|---|
| X | 0 | 1 | 2 | 4 | 7 |
| f(X) = Y | 0 | 1 | 3 | 12 | 20 |

fit a curve of the form

$$f(X) = Y - A + BX + CX^2$$

STEP 1: Substitute all pairs of data into the form equation yielding the fact that the coefficients (A, B and C) must satisfy all the following:

$$0 = A + B(0) + C(0)^2$$

$$1 = A + B(1) + C(1)^2$$

$$3 = A + B(2) + C(2)^2$$

$$12 = A + B(4) + C(4)^2$$

$$20 = A + B(7) + C(7)^2$$

Now multiply each expression by its coefficient of A in that expression and add all equation yielding

$$36 = 5A + 14B + 70C$$

Now multiply each expression by its coefficient of B in that expression and add all the equations yielding

$$\begin{array}{rcl} 0 &=& 0(A) + 0(B) + 0(C) \\ 1 &=& A + 1B + 1C \\ 6 &=& 2A + 4(B) + 8(C) \\ 48 &=& 4A + 16(B) + 64(C) \\ 140 &=& 7A + 44(B) + 343(C) \\ \hline 195 &=& 14A + 70(B) + 416(C) \end{array}$$

Now multiply each expression by its coefficient C in that expression and add all the expressions yielding

$$\begin{array}{rcl} 0 &=& 0(A) + 0(B) + 0(C) \\ 1 &=& 1(A) + 1(B) + 1(C) \\ 12 &=& 4(A) + 8(B) + 16(C) \\ 192 &=& 16(A) + 64(B) + 256(C) \\ 980 &=& 49(A) + 343(B) + 2401(C) \\ \hline 1185 &=& 70A + 416B + 2674C \end{array}$$

Now solve the following three previously generated equations for the coefficients A, B and C yielding

$$\begin{array}{rcl} 36 &=& 5A + 14B + 70C \\ 195 &=& 14A + 70B + 416C \\ 1185 &=& 70A + 416B + 2674C \end{array}$$

$$A = -.99,\ B = 2.6,\ C = .065$$

and

$$Y = -.99 + 2.6X + .065X^2$$

The following plot and chart depict the original data and the data obtained from the equation for the fitted curve:

| | Original | Fitted Curve Polynomial |
|---|---|---|
| X | Y | Y |
| 0 | 0 | -.98 |
| 1 | 1 | 1.67 |
| 2 | 3 | 4.48 |
| 4 | 12 | 10.46 |
| 7 | 20 | 20.41 |

Q.E.D.

## APPENDIX B

## NATOPS Manual Performance Charts

These charts from which the performance algorithms were developed are listed below in order:

| Figure | Title |
|---|---|
| B1 | Cruise Performance, Phase I |
| B2 | Cruise Performance, Phase II |
| B3 | Cruise Performance, Phase III |
| B4 | Cruise Performance, Phase IV |
| B5 | Takeoff Factor |
| B6 | Takeoff Ground Roll Distance |
| B7 | Adjusted Takeoff Ground Roll Distance |
| B8 | Maximum Range Cruise at Constant Altitude (Time, Speed) |
| B9 | Maximum Range Cruise at Constant Altitude (Fuel Required) |
| B10 | Military Power Climb Schedule |
| B11 | Takeoff Speed |
| B12 | Maximum Refusal Speed |
| B13 | Cruise Ceiling and Optimum Endurance Altitude |

## CRUISE PERFORMANCE (A-7E)

### PHASE I – CLEAN AIRPLANE TRANSFER SCALE

MODEL: A-7E
DATA BASIS: FLIGHT TEST
DATE: NOVEMBER 1971

ENGINE: TF41-A-2
FUEL GRADE: JP-5
FUEL DENSITY: 6.8 LB/GAL

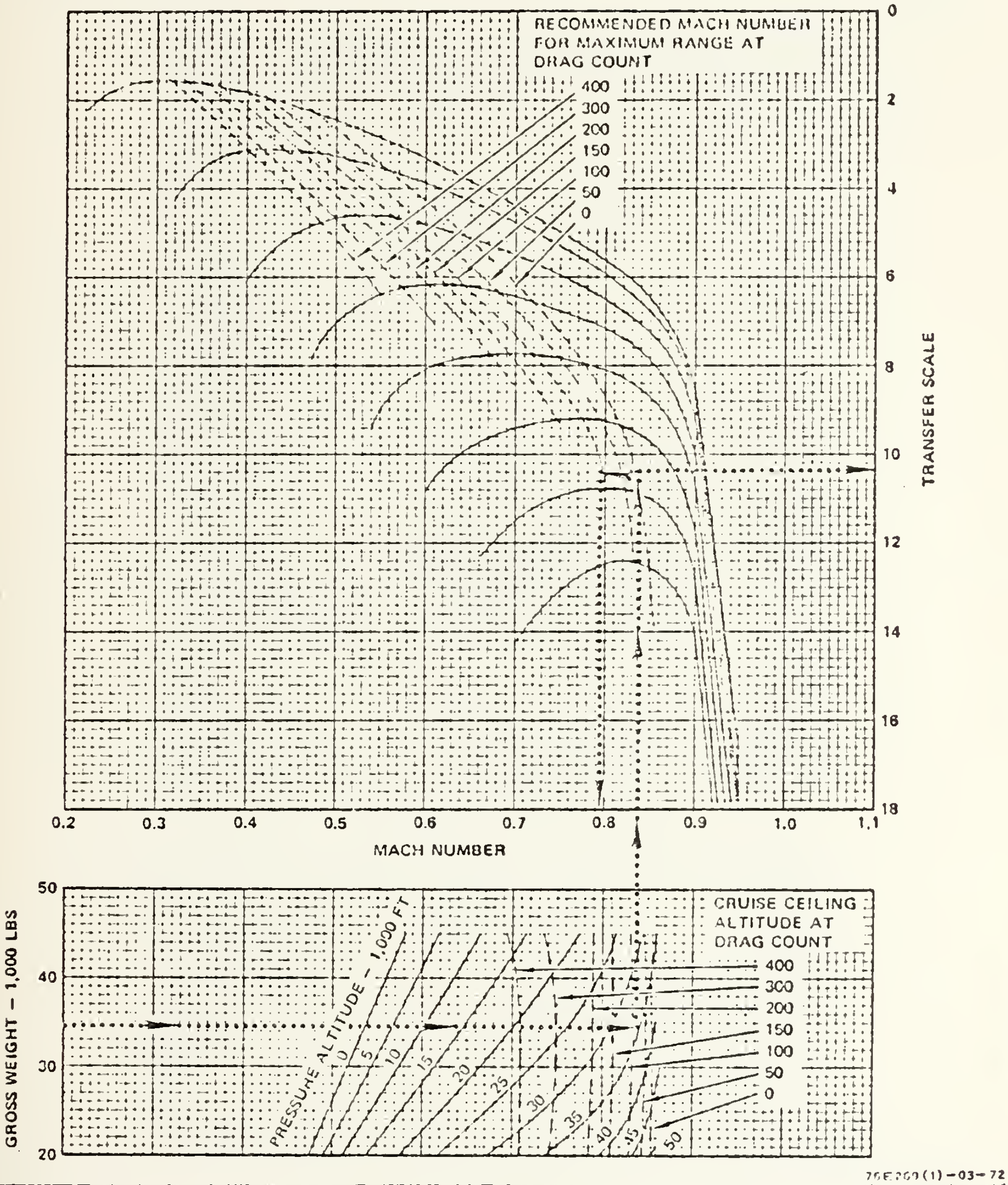





Figure B1

Cruise Performance, Phase I

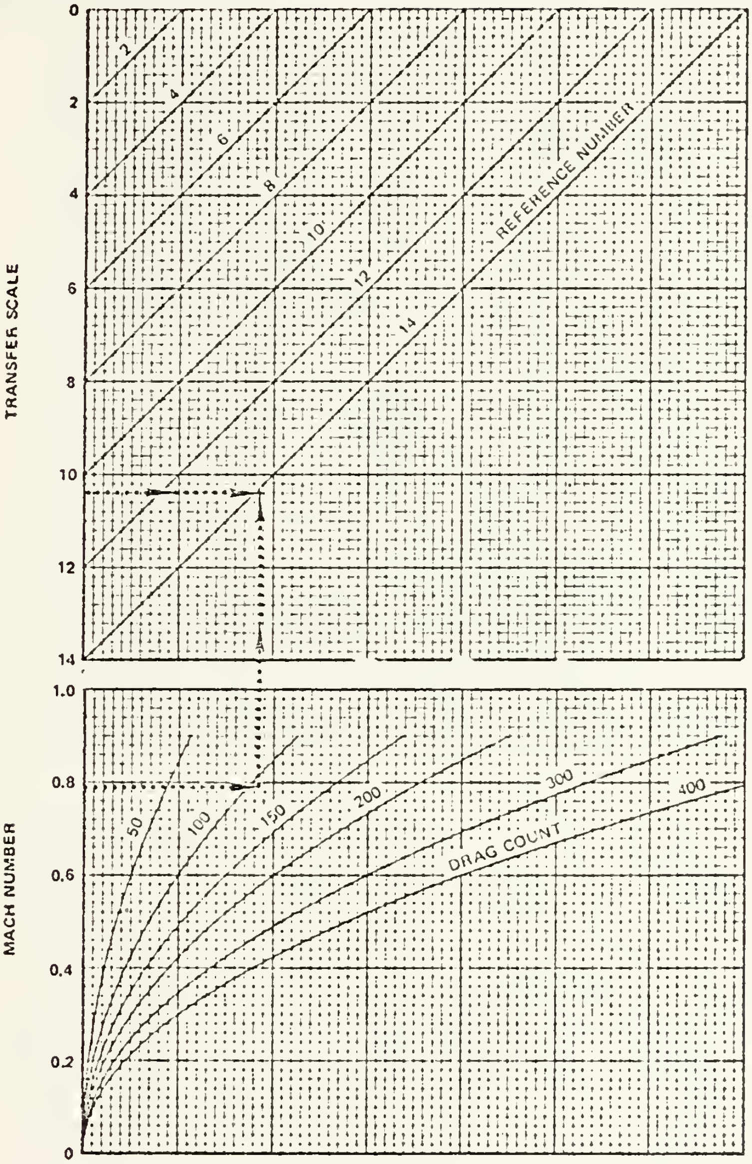
# CRUISE PERFORMANCE (A-7E)

11–117

## PHASE II – AIRCRAFT REFERENCE NUMBER

MODEL: A-7E
DATA BASIS: FLIGHT TEST
DATE: NOVEMBER 1971

ENGINE: TF41-A-2
FUEL GRADE: JP-5
FUEL DENSITY: 6.8 LB/GAL




76E769(2)-03-72



Figure B2

Cruise Performance, Phase II

## CRUISE PERFORMANCE (A-7E)

PHASE III – POUNDS OF FUEL PER NAUTICAL MILE

MODEL: A-7E
DATA BASIS: FLIGHT TEST
DATE: NOVEMBER 1971

ENGINE: TF41-A-2
FUEL GRADE: JP-5
FUEL DENSITY: 6.8 LB/GAL

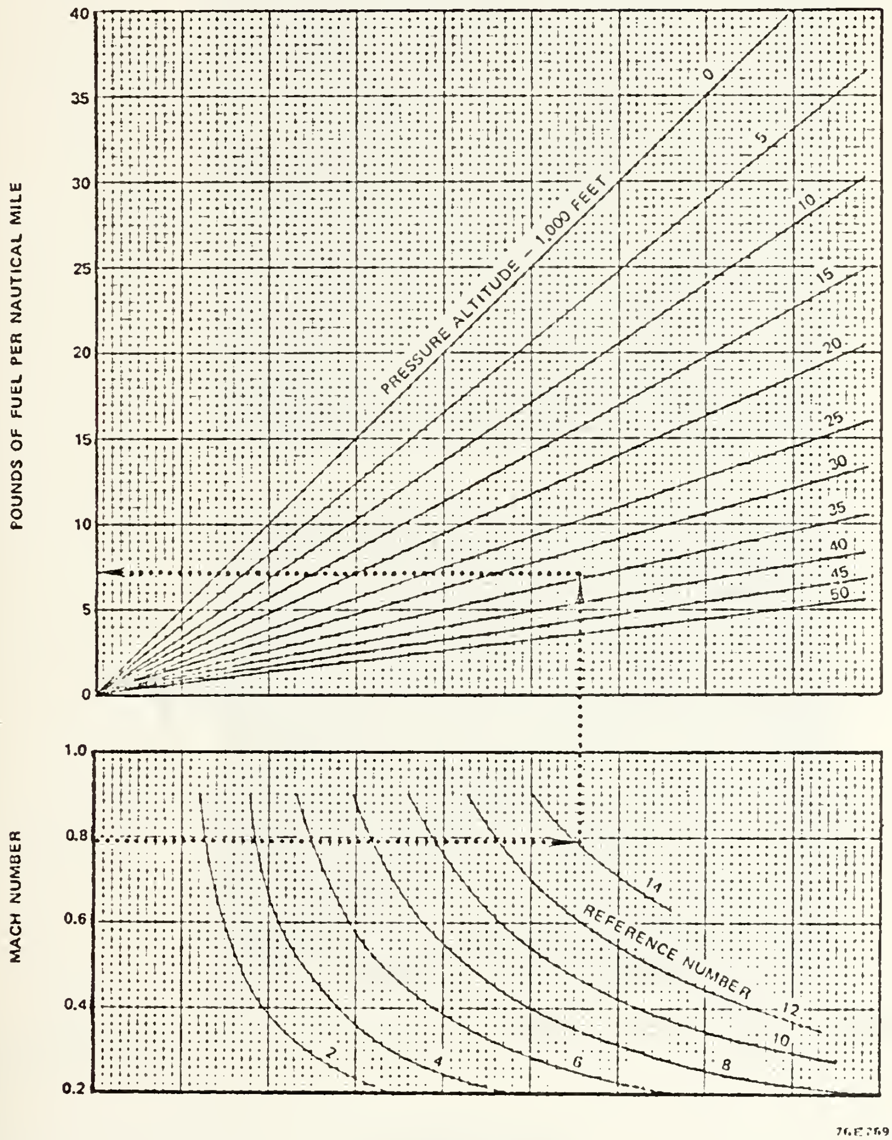





Figure B3

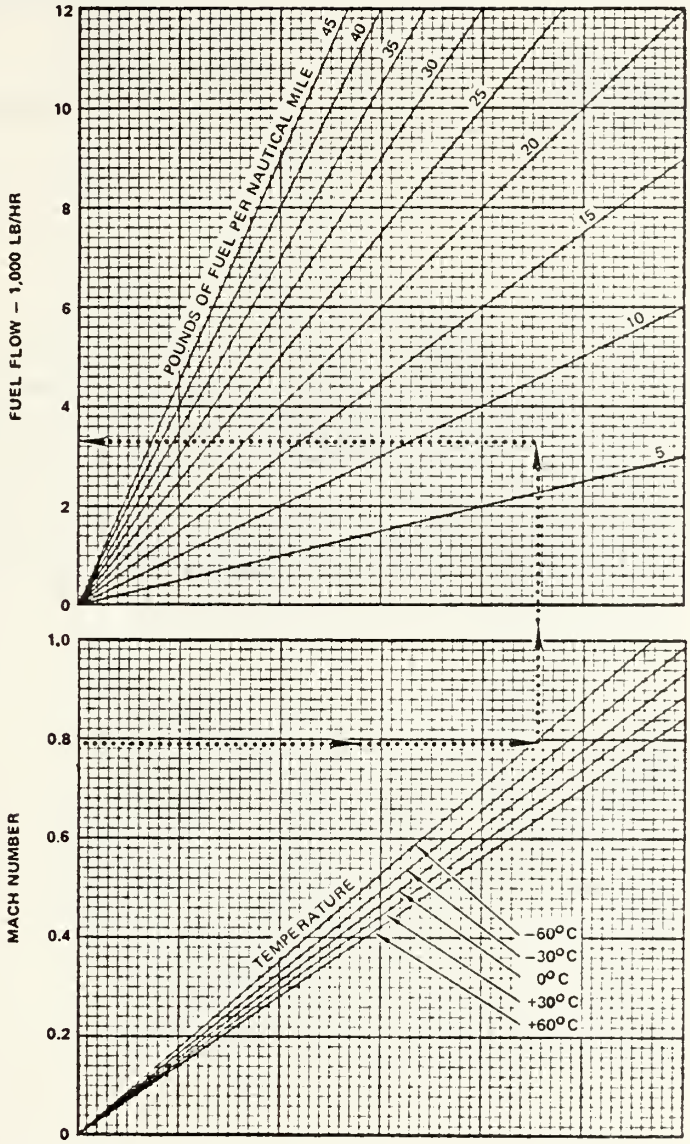
Cruise Performance, Phase III

# CRUISE PERFORMANCE (A-7E)

## PHASE IV – FUEL FLOW

MODEL: A-7E
DATA BASIS: FLIGHT TEST
DATE: NOVEMBER 1971

ENGINE: TF41-A-2
FUEL GRADE: JP-5
FUEL DENSITY: 6.8 LB/GAL




76E269(4)–03–72



Figure B4

Cruise Performance, Phase IV

# TAKEOFF FACTOR (A-7E)

MODEL: A-7E
DATA BASIS: FLIGHT TEST
DATE: NOVEMBER 1971

ENGINE: TF41-A-2
FUEL GRADE: JP-5
FUEL DENSITY: 6.8 LB/GAL.

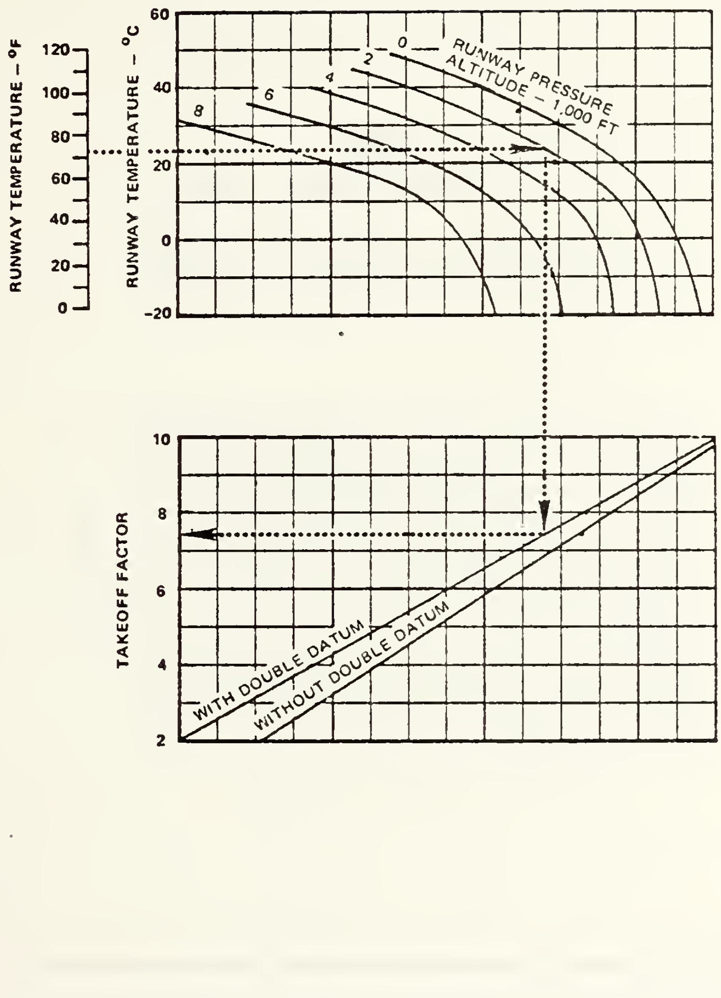





Figure B5

Takeoff Factor

# TAKEOFF GROUND ROLL DISTANCE (A-7E)

MODEL: A-7E
DATA BASIS: FLIGHT TEST
DATE: NOVEMBER 1971

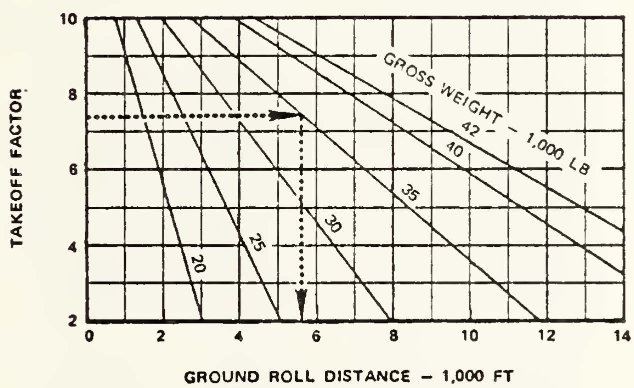
CONDITIONS:
LEVEL HARD SURFACE RUNWAY
MILITARY RATED THRUST
LANDING CONFIGURATION
ZERO HEADWIND
CG: 26% MAC
FULL FLAPS

ENGINE: TF41-A-2
FUEL GRADE: JP-5
FUEL DENSITY: 6.8 LB/GAL.

**NOTE**

For minimum ground roll corresponding to minimum lift-off speed, subtract 500 feet.

For humidity effects on takeoff distance, ground roll distances should be increased 1% for each 10% increase in the relative humidity above 40%.




76E287(1)-04-74



Figure B6

Takeoff Ground Roll Distance

# TAKEOFF GROUND ROLL DISTANCE (A-7E)

## ADJUSTED GROUND ROLL DISTANCE

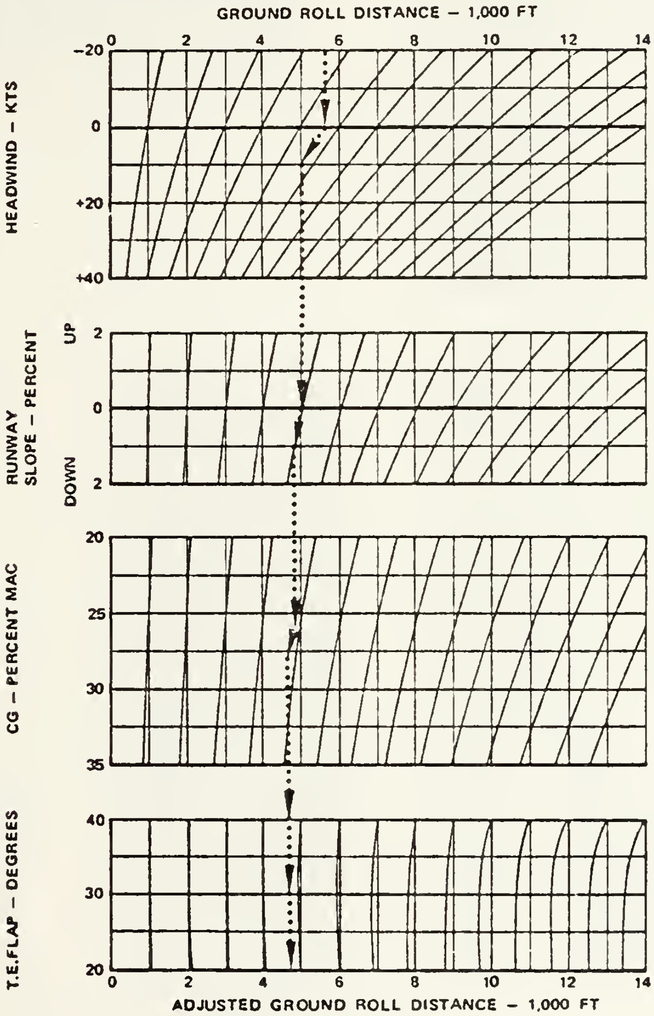
MODEL: A-7E
DATA BASIS: FLIGHT TEST
DATE: NOVEMBER 1971

CONDITIONS:
HARD SURFACE RUNWAY
MILITARY RATED THRUST
LANDING CONFIGURATION
LEADING EDGE FLAPS DOWN

ENGINE: TF41-A-2
FUEL GRADE: JP-5
FUEL DENSITY: 6.8 LB/GAL.

**NOTE**

For humidity affects on takeoff distance, ground roll distances should be increased 1% for each 10% increase in the relative humidity above 40%.




76E287(2)-02-72



Figure B7

Adjusted Takeoff Ground Roll Distance

# MAXIMUM RANGE CRUISE AT CONSTANT ALTITUDE (A-7E)

ENGINE: TF41-A-2
FUEL GRADE: JP-5
FUEL DENSITY: 6.8 LB/GAL

## TIME AND SPEED

MODEL: A-7E
DATA BASIS: FLIGHT TEST
DATE: NOVEMBER 1971

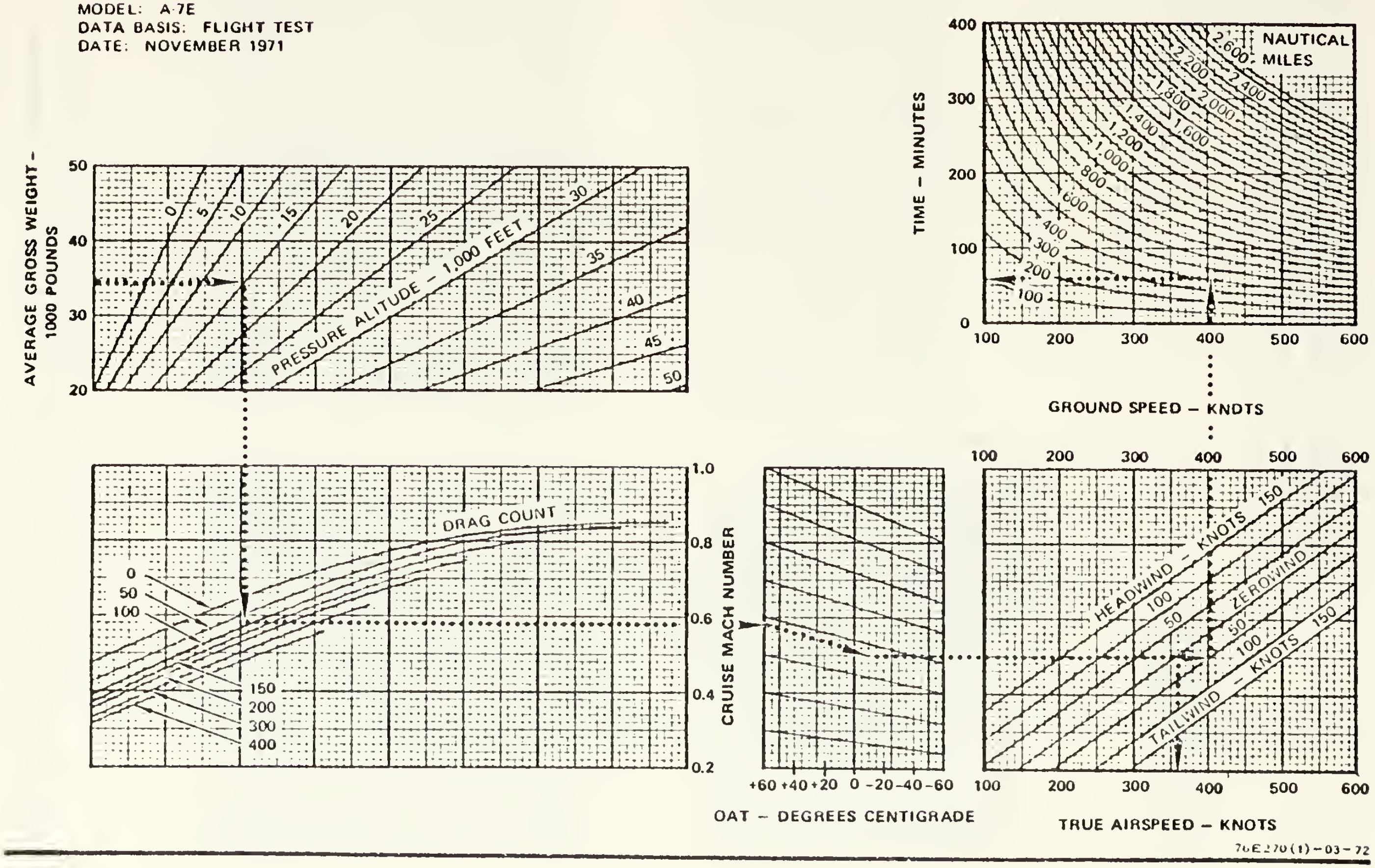



Figure B8

Maximum Range Cruise at Constant Altitude (Time, Speed)

# MAXIMUM RANGE CRUISE AT CONSTANT ALTITUDE (A-7E)

## FUEL REQUIRED

MODEL: A-7E
DATA BASIS: FLIGHT TEST
DATE: NOVEMBER 1971

ENGINE: TF41-A-2
FUEL GRADE: JP-5
FUEL DENSITY: 6.8 LB/GAL

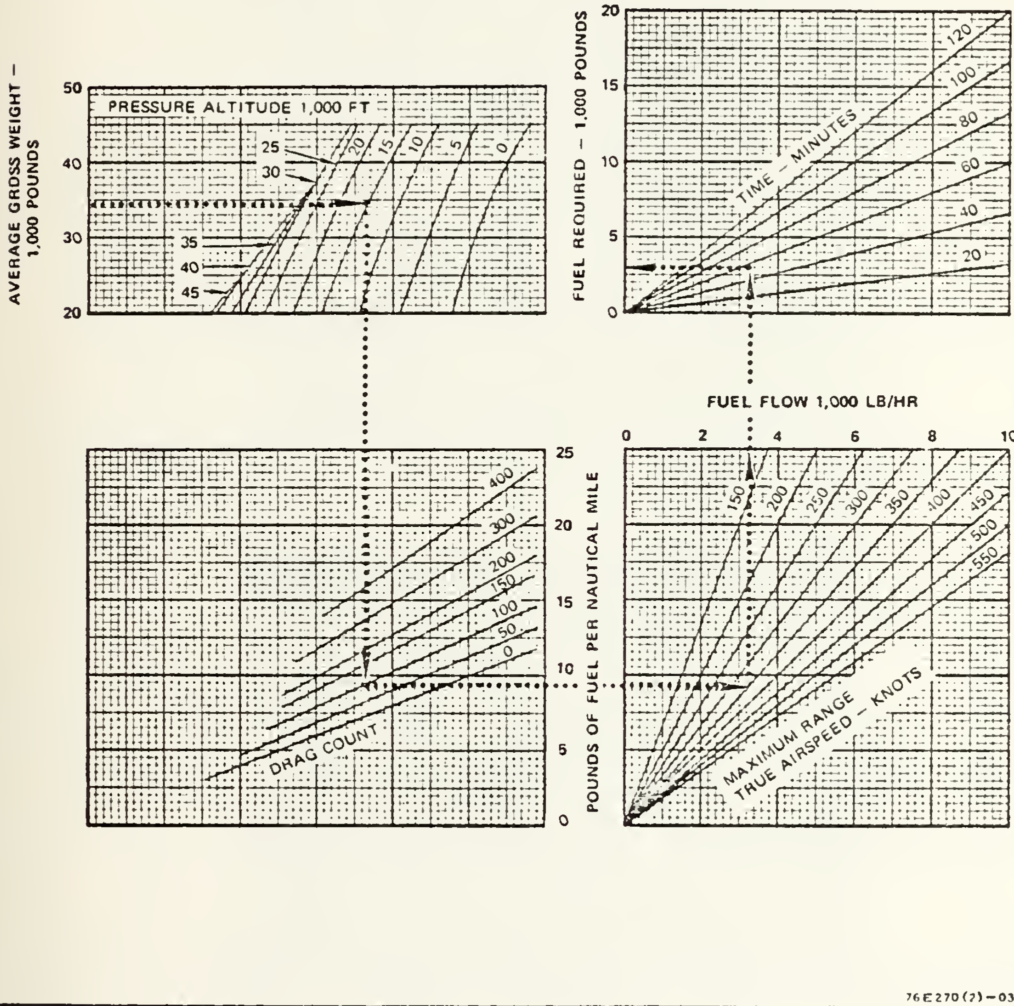





Figure B9

Maximum Range Cruise at Constant Altitude (Fuel Required)

# MILITARY POWER CLIMB (A-7E)

## CLIMB SPEED SCHEDULE

MODEL: A-7E
DATA BASIS: FLIGHT TEST
DATE: NOVEMBER 1971

ENGINE: TF41-A-2
FUEL GRADE: JP-5
FUEL DENSITY: 6.8 LB/GAL

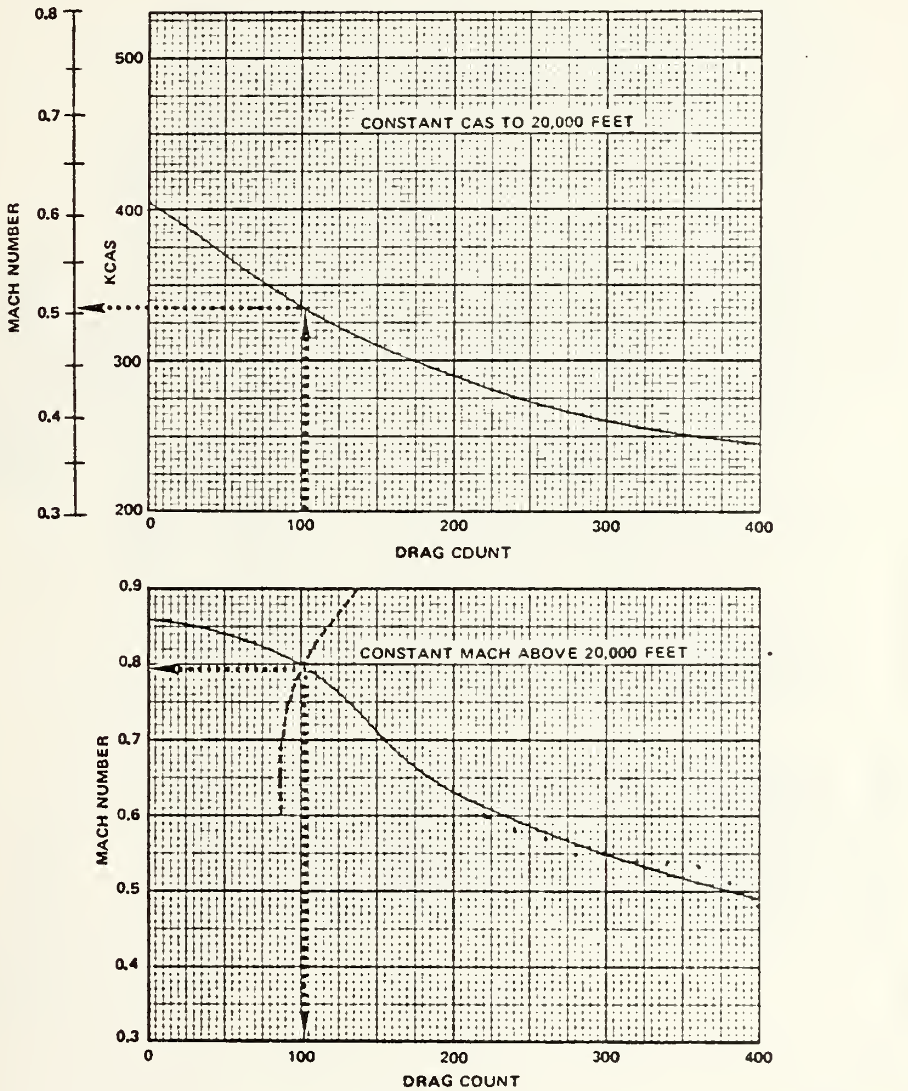





Figure B10

Military Power Climb Schedule

# TAKEOFF SPEED (A-7E)

MODEL: A-7E
DATA BASIS: FLIGHT TEST
DATE: NOVEMBER 1971

CONDITIONS:
MILITARY RATED THRUST
LANDING CONFIGURATION
LEADING EDGE FLAPS DOWN

ENGINE: TF41-A-2
FUEL GRADE: JP-5
FUEL DENSITY: 6.8 LB/GAL

**NOTE**

Data basis is 26% MAC. Increase speed 1/2 knot per 1% forward CG shift. Decrease speed 1/2 knot per 1% aft CG shift.

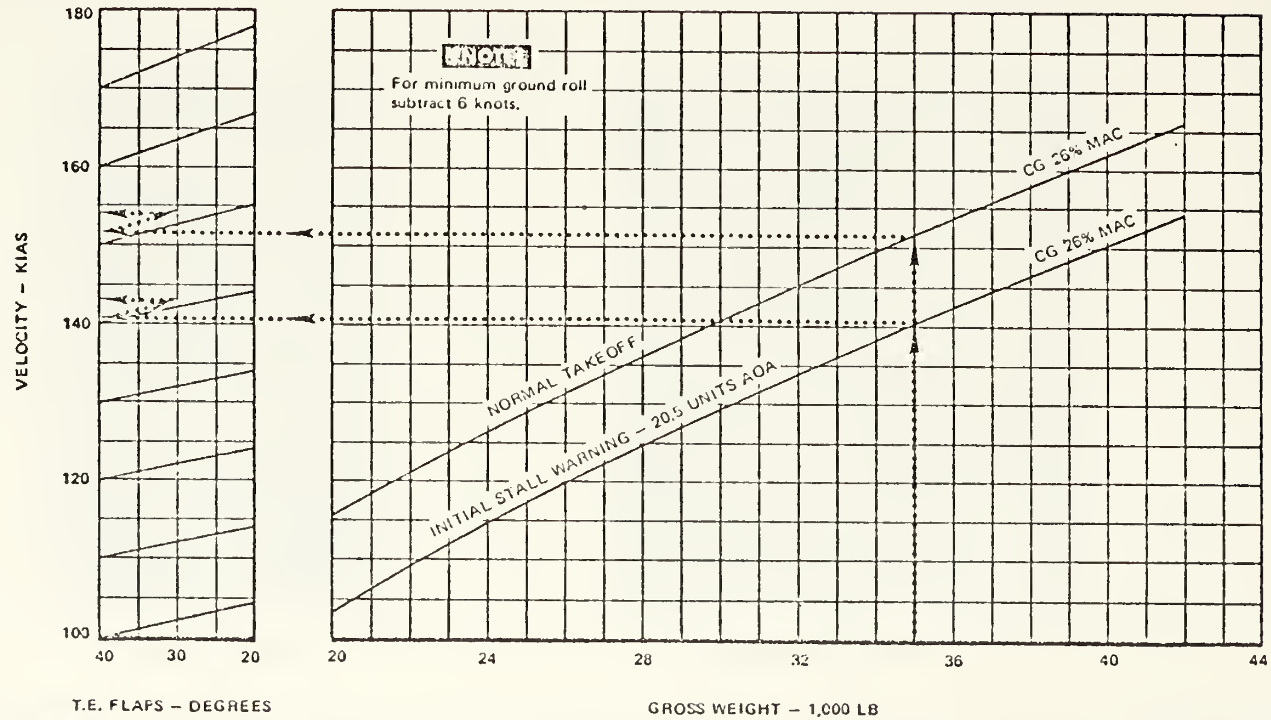





Figure B11

Takeoff Speed

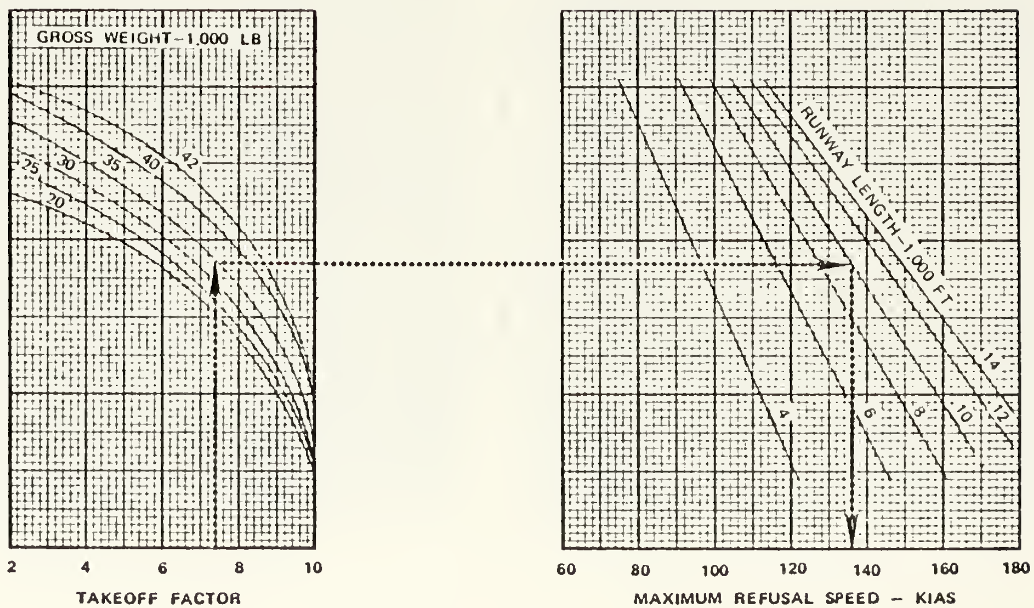
# MAXIMUM REFUSAL SPEED (A-7E)

WITH ANTI-SKID

MODEL: A-7E
DATA BASIS: FLIGHT TEST
DATE: NOVEMBER 1971

CONDITIONS:
MILITARY RATED THRUST
HARD SURFACE RUNWAY
LANDING CONFIGURATION

ENGINE: TF41-A-2
FUEL GRADE: JP-5
FUEL DENSITY: 6.8 LB/GAL




76E291-04-74

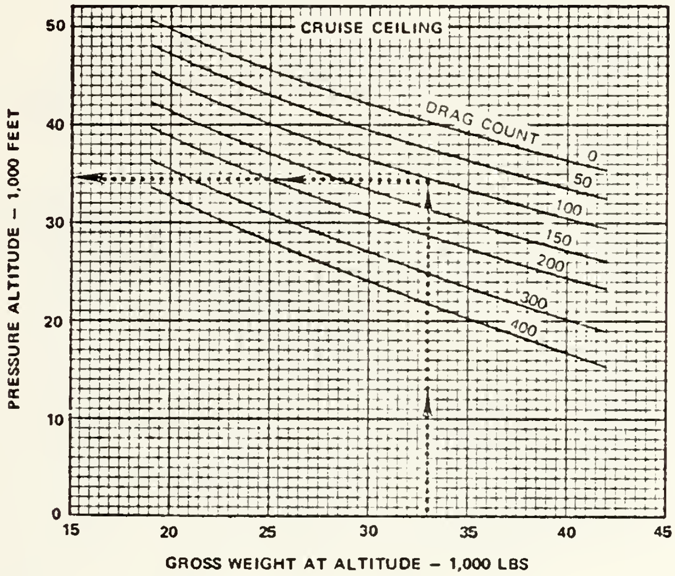
Figure B12

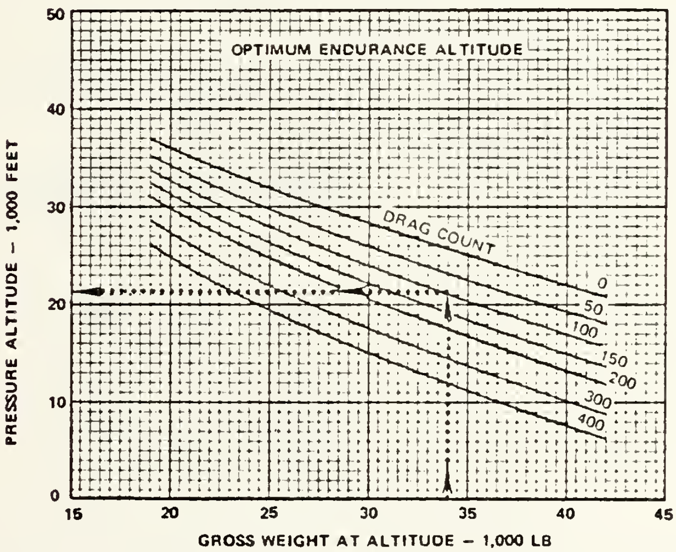
Maximum Refusal Speed

# CRUISE CEILING AND OPTIMUM ENDURANCE ALTITUDE (A-7E)

MODEL: A-7E
DATA BASIS: FLIGHT TEST
DATE: NOVEMBER 1971

ENGINE: TF41-A-2
FUEL GRADE: JP-5
FUEL DENSITY: 6.8 LB/GAL




76E267-03-72



Figure B13

Cruise Ceiling and Optimum Endurance Altitude

## APPENDIX C

## Generated Algorithms

### LOW LEVEL CRUISE PROGRAM

Phase I

$$M1 = -92.512 + 236.896G$$

Transfer Scale Versus Drag Count

$$A0 = -2.3287 - .26316D + .0073327D^2 - (7.513E-5)D^3 + (3.5396E-7)D^4 - (7.78E-10)D^5 + (6.462E-13)D^6$$

$$A1 = 4.835 + 1.0956D - .030653D^2 + (3.1912E-4)D^3 - (1.5276E-6)D^4 + (3.408E-9)D^5 - (2.8692E-12)D^6$$

$$A2 = 10.284 - 1.0719D + .031094D^2 - (3.2878E-4)D^3 + (1.595E-6)D^4 - (3.6009E-9)D^5 + (3.0634E-12)D^6$$

$$S1 = A0 + (A1)(M1) + (A2)(M1)^2$$

Transfer Scale Versus Guidelines

$$B0 = 22.819 - 31.734I + 41.33I^2 - 5.0953I^3$$

$$B1 = -154.98 + 217.51I - 261.73I^2 + 35.905I^3$$

$$B2 = 405.08 - 525.56I + 607.49I^2 - 88.737I^3$$

$$B3 = -445.62 + 542.98I - 611.55I^2 + 92.894I^3$$

$$B4 = 184.78 - 204.42I + 225.89I^2 - 35.189I^3$$

$$S = B0 + (B1)(M1) + (B2)(M1)^2 + (B3)(M1)^3 + (B4)(M1)^4$$

Phase II

$$R = S + 2[(4.3732E-3) + .027743D]M^2$$

Phase III

$$B0 = 5.6253 - 1.989R + 3.0252R^2 - 1.0761R^3 + .17675R^4 - .013095R^5 + (3.526E-4)R^6$$

$$B1 = 205.3012 - 248.9317R + 91.66355R^2 - 15.55218R^3 + 1.224432R^4 - .0395333R^5 + (2.896385E-4)R^6$$

$$B2 = -1052.123 + 1231.24R - 487.4233R^2 + 91.6522R^3 - 8.662962R^4 + .3953974R^5 - .006905535R^6$$

$$B3 = 1680.142 - 1950.139R + 788.8513R^2 - 152.5733R^3 + 15.03819R^4 - .7274139R^5 + .013707R^6$$

$$R3 = R$$

$$R1 = 2\ (\text{Integer}\ (R/2))$$

$$R2 = R1 + 2$$

$$N1 = B0 + (B1)(R1) + (B2)(R1)^2 + (B3)(R1)^3$$

$$N2 = B0 + (B1)(R2) + (B2)(R2)^2 + (B3)(R2)^3$$

Using Linear Interpolation

$$N = N1 + [(N2-N1)(R3-R1)/2]$$

$$P = 4.9746N + (7.9043E-6)N^2$$

Phase IV

$$N4 = [6.4375 + .010426T - (6.8925E-6)T^2 + (4.9127E-7)T^3]M$$

$$F = .1(N4)P$$

## TAKEOFF DISTANCE PROGRAM

$$B0 = 13.086 - .00017113A - (2.0655E-7)A^2 + (3.6861E-11)A^3 - (2.4156E-15)A^4$$

$$B1 = -.045635 - (7.8931E-6)A + (3.7545E-9)A^2 - (9.7088E-13)A^3 + (6.997E-17)A^4$$

$$B2 = -.001317 - (8.2558E-7)A + (4.0739E-10)A^2 - (8.548E-14)A^3 + (5.4964E-18)A^4$$

$$B3 = -(1.9097E-5) + (1.3671E-8)A - (9.4694E-12)A^2 + (2.0434E-15)A^3 - (1.4617E-19)A^4$$

$$C = B0 + B1(B) + B2(B)^2 + B3(B)^3$$

If double datum on,

$$E = 1.9773 + .56598C$$

If double datum off,

$$E = .54178 + .65876C$$

$$G0 = -(4.8896E+5) + (8.4974E+1)G - (5.7856E-3)G^2 + (1.9373E-7)G^3 - (3.1744E-12)G^4 + (2.0446E-17)G^5$$

$$G1 = (5.8621E+4) - (1.0146E+1)G + (6.8807E-4)G^2 - (2.292E-8)G^3 + (3.7387E-13)G^4 - (2.3964E-18)G^5$$

$$H = G0 + G1(E)$$

If relative humidity < 40%, K = H

If not, $K = 4\{[(I-40)/1000]+1\}$

$$L0 = 67.124 + .89509K + (2.3306E-5)K^2 - (1.6254E-9)K^3 + (3.3728E-14)K^4$$

$$L1 = -9.0995 - (1.0856E-2)K + (2.1754E-7)K^2 - (2.5327E-11)K^3 + (1.197E-15)K^4$$

$$L2 = (1.4782E-1) - (2.1666E-6)K + (3.4274E-9)K^2 - (2.7817E-13)K^3 + (9.3077E-18)K^4$$

$$M = L0 + L1(L) + L2(L)^2$$

If winds calm, M = K

$$X0 = (4.5704E{+}1) + .93429M + (2.2265E{-}5)M^2 - (2.338E{-}9)M^3 + (7.941E{-}14)M^4$$

$$X1 = 7.9472 + .014914M + (9.0708E{-}6)M^2 - (7.1235E{-}10)M^3 + (3.0684E{-}14)M^4$$

$$X2 = 5.3616 - .0085136M + (3.5914E{-}6)M^2 - (4.5932E{-}10)M^3 + (1.9889E{-}14)M^4$$

$$X = X0 + X1(N) + X2(N)^2$$

$$Q0 = 2604.2 - 2.1694X + .0010915X^2 - (1.1119E{-}7)X^3 + (3.662E{-}12)X^4$$

$$Q1 = -175.73 + .22601X - (7.5225E{-}5)X^2 + (7.7018E{-}9)X^3 - (2.5437E{-}13)X^4$$

$$Q2 = 2.8549 - .0040102X + (1.2832E{-}6)X^2 - (1.3234E{-}10)X^3 + (4.3908E{-}15)X^4$$

$$Q = Q0 + Q1(P) + Q2(P)^2$$

$$S0 = -400.79 + 1.5801Q - (2.0254E{-}4)Q^2 + (2.4111E{-}8)Q^3 - (8.6737E{-}13)Q^4$$

$$S1 = 16.196 - .024333Q + (9.3484E{-}6)Q^2 - (1.2594E{-}9)Q^3 + (4.7522E{-}14)Q^4$$

$$S2 = -.14758 + (2.359E{-}4)Q - (1.037E{-}7)Q^2 + (1.6016E{-}11)Q^3 - (6.3195E{-}16)Q^4$$

$$S = S0 + S1(R) + S2(R)^2$$

## MAXIMUM RANGE CRUISE TIME AND SPEED AT CONSTANT ALTITUDE PROGRAM

$$B0 = -1 + (5.0794E{-}3)H - (1.3968E{-}3)H^2 + (8.254E{-}5)H^3 - (1.2698E{-}6)H^4$$

$B1 = .05 + .0015159H + (1.123E\text{-}4)H^2 - (3.4921E\text{-}6)H^3$
$+ (7.9365E\text{-}8)H^4$

$N = B0 + B1(G)$

$B0 = .47803 + .0013417D + (6.2287E\text{-}6)D^2 - (1.6261E\text{-}8)D^3$
$+ (1.6438E\text{-}11)D^4$

$B1 = .08217 + (4.1209E\text{-}4)D - (4.5577E\text{-}6)D^2 + (1.6777E\text{-}8)D^3$
$- (2.001E\text{-}11)D^4$

$B2 = (4.2143E\text{-}4) - (9.4397E\text{-}5)D + (1.2646E\text{-}6)D^2 - (4.8537E\text{-}9)D^3$
$+ (5.7222E\text{-}12)D^4$

$B3 = -(6.6767E\text{-}4) + (8.4671E\text{-}6)D - (1.0501E\text{-}7)D^2 + (3.6382E\text{-}10)D^3$
$- (3.7828E\text{-}13)D^4$

$M = B0 + B1(N) + B2(N)^2 + B3(N)^3$

$M1 = M - [(60-T)(2)(M)/1200]$

$V = (710)(M1 - .14) + 100 - E$

$T1 = D1/V$

## FUEL REQUIRED FOR MAXIMUM RANGE CRUISE AT CONSTANT ALTITUDE PROGRAM

$B0 = 4.54 - .16444A + .0033932A^2 - (1.0283E\text{-}4)A^3 + (1.926E\text{-}6)A^4$
$- (1.3757E\text{-}8)A^5$

$B1 = (3.22E\text{-}9) - (3.6664E\text{-}3)A + (8.9338E\text{-}4)A^2 - (5.5939E\text{-}5)A^3$
$+ (1.4593E\text{-}6)A^4 - (1.3281E\text{-}8)A^5$

$B2 = (6E\text{-}4) + (1.1203E\text{-}4)A - (2.3358E\text{-}5)A^2 + (1.4536E\text{-}6)A^3$
$- (3.7144E\text{-}8)A^4 + (3.3334E\text{-}10)A^5$

$N = B0 + B1(G) + B2(G)^2$

$$B0 = -(2.5399E-3)D + (9.7299E-5)D^2 - (2.3516E-7)D^3 + (1.4251E-10)D^4$$

$$B1 = 2 + (4.2388E-3)D + (1.2326E-5)D^2 - (1.0298E-7)D^3 + (1.7277E-10)D^4$$

$$L = B0 + B1(N)$$

$$F = L/V$$

$$R = (F)(T)/60$$

MAXIMUM RANGE CLIMB AIRSPEED SCHEDULE

$$S = 405.56 - .79075D + .0011382D^2 - (4.1018E-7)D^3$$

$$M = .86 - (2.1634E-3)D + (7.6582E-5)D^2 - (1.1344E-6)D^3 + (7.2125E-9)D^4 - (2.3035E-11)D^5 + (3.6588E-14)D^6 - (2.3062E-17)D^7$$

TAKEOFF AIRSPEED PROGRAM

$$U1 = 54.023 + (3.4787E-3)G - (1.9475E-8)G^2$$

$$U = U1 + [(26-P)/2]$$

$$V0 = -1917.1 + 61.604U - .70348U^2 + .0035661U^3 - (6.6578E-6)U^4$$

$$V1 = 76.824 - 2.4517U + .028779U^2 - (1.4753E-4)U^3 + (2.7872E-7)U^4$$

$$V2 = -.72239 + .023415U - (2.798E-4)U^2 + (1.4596E-6)U^3 - (2.807E-9)U^4$$

$$V3 = V0 + V1(R) + V2(R)^2$$

MAXIMUM REFUSAL SPEED PROGRAM

$$B0 = -43.01 + 6.761G - .35159G^2 + .0080545G^3 - (6.7769E-5)G^4$$

$$B1 = 26.312 - 3.8382G + .20326G^2 - .047022G^3 + (3.994E-5)G^4$$

$B2 = -4.9639 + .72723G - .038721G^2 + (8.985E-4)G^3 - (7.638E-6)G^4$

$B3 = .30288 - .044855G - .0023921G^2 - (5.5549E-5)G^3$

$+ (4.7217E-7)G^4$

$R = B0 + B1(E) + B2(E)^2 + B3(E)^3$

$B0 = -11.412 + 62.185L - 9.0037L^2 + .64921L^3 - .017455L^4$

$B1 = -.2811 - 4.2012L + .70377L^2 - .058693L^3 + .0017461L^4$

$M = B0 + B1(R)$

## OPTIMUM ENDURANCE ALTITUDE PROGRAM

$B0 = 55.333 + .073076D - (9.7836E-4)D^2 + (3.5015E-6)D^3$

$- (3.9782E-9)D^4$

$B1 = -1.1 - (8.0597E-3)D + (8.0097E-5)D^2 - (2.8836E-7)D^3$

$+ (3.3032E-10)D^4$

$B2 = (6.6667E-3) + (1.2541E-4)D - (1.4039E-6)D^2$

$H = B0 + B1(G) + B2(G)^2$

## CRUISE CEILING PROGRAM

$B0 = 85.118 - .29117D + .0030434D^2 - (1.2851E-5)D^3 + (1.6621E-8)D^4$

$B1 = -2.7877 + .025635D - (3.3063E-4)D^2 + (1.4162E-6)D^3$

$- (1.8343E-9)D^4$

$B2 = .063327 - (8.5289E-4)D + (1.0814E-5)D^2 - (4.6514E-8)D^3$

$+ (6.0606E-11)D^4$

$B3 = -(6.0468E-4) + (9.0826E-6)D - (1.143E-7)D^2 + (4.9304E-10)D^3$

$- (6.4567E-13)D^4$

$H = B0 + (B1)G + (B2)G^2 + (B3)G^3$

# APPENDIX D

## HP-9830 Programs and Lists of Variables

```
1 REM THIS PROGRAM CALCULATES THE FUEL FLOW AND LBFUEL/NAUTICAL MILE FOR AN
2 REM A-7E FLYING A LOW LEVEL MISSION AND IS DEPENDENT ON 4 VARIABLES --
3 REM GROSS WEIGHT,DRAG COUNT,MACH NUMBER, AND TEMPERATURE(CENTIGRADE)
10 PRINT "ENTER GROSS WT,DRAG CT, MACH #, AND TEMP(CENT)"
11 PRINT
12 PRINT
20 INPUT G,D,M,T
49 G=G/1000
50 M1=0.38813+0.0042981*G
54 GOSUB 800
56 I=0
58 GOSUB 600
60 S2=S
70 IF S1>S2 THEN 100
90 S=S2
95 GOTO 300
100 I=1
110 GOSUB 600
120 S3=S
130 IF S1<S3 THEN 200
140 S2=S3
150 I=I+1
160 GOSUB 600
170 GOTO 120
200 I1=(S1-S2)/(S3-S2)
210 M1=M
220 I=I-1+I1
221 I=INT(I)
222 GOSUB 600
223 S2=S
224 I=I+1
225 GOSUB 600
226 S3=S
227 S=S2+(I1*(S3-S2))
240 GOTO 300
285 PRINT
286 PRINT
300 R=S+2*(4.3732E-03+0.027743*D)*M↑2
301 R3=R
302 R1=2*INT(R/2)
304 R2=R1+2
306 J=1
308 IF J=2 THEN 311
309 R=R1
310 GOTO 319
311 R=R2
319 B0=5.6253-1.989*R+3.0252*R↑2-1.0761*R↑3+0.17675*R↑4
320 B0=B0-0.013095*R↑5+3.526E-04*R↑6
330 B1=205.3012-248.9317*R+91.66355*R↑2-15.55218*R↑3+1.224432*R↑4
340 B1=B1-0.0395333*R↑5+2.896385E-04*R↑6
350 B2=-1052.123+1231.24*R-487.4233*R↑2+91.6522*R↑3-8.662962*R↑4+0.3953974*R↑5
360 B2=B2-0.006905535*R↑6
370 B3=1680.142-1950.139*R+788.8513*R↑2-152.5733*R↑3+15.03819*R↑4
380 B3=B3-0.7274139*R↑5+0.013707*R↑6
390 B4=-864.6875+1000.443*R-408.7451*R↑2+80.08314*R↑3-8.02958*R↑4
400 B4=B4+0.3982527*R↑5-7.720617E-03*R↑6
430 N=B0+B1*M+B2*M↑2+B3*M↑3+B4*M↑4
440 IF J=2 THEN 480
450 N1=N
```

```
455 J=2
460 GOTO 311
475 R=2
480 N2=N
490 N=N1+(N2-N1)*(R3-R1)/2
500 REM       COMPLETED CALCULATION OF INTERMEDIATE # BY LINEAR INTERPOLATION
510 P=4.9746*N+7.9043E-06*N↑2
520 N4=(6.4375+0.010426*T-6.8925E-06*T↑2+4.9127E-07*T↑3)*M
530 F=(0.1*N4*P)*1000
539 F=INT(F)
540 PRINT "GROSS WT="G*1000
541 PRINT "TS="S"DC="D"M="M
542 PRINT "TEMP="T
543 PRINT "REF #="R3
544 PRINT "N="N
545 PRINT "LBFUEL NM="P
550 PRINT "FUEL FLOW=  "F
551 PRINT
555 GOTO 10
600 B0=22.819-31.734*I+41.33*I↑2-5.0953*I↑3
610 B1=-154.98+217.51*I-261.73*I↑2+35.905*I↑3
620 B2=405.08-525.56*I+607.49*I↑2-88.737*I↑3
630 B3=-445.62+542.98*I-611.55*I↑2+92.894*I↑3
640 B4=184.78-204.42*I+225.89*I↑2-35.189*I↑3
650 S=B0+B1*M1+B2*M1↑2+B3*M1↑3+B4*M1↑4
660 RETURN
800 A0=-2.3287-0.26316*D+0.0073327*D↑2-7.513E-05*D↑3+3.5396E-07*D↑4
810 A0=A0-7.78E-10*D↑5+6.4624E-13*D↑6
820 A1=4.835+1.0956*D-0.030653*D↑2+3.1912E-04*D↑3-1.5276E-06*D↑4
830 A1=A1+3.408E-09*D↑5-2.8692E-12*D↑6
840 A2=10.284-1.0719*D+0.031094*D↑2-3.2878E-04*D↑3+1.595E-06*D↑4
850 A2=A2-3.6009E-09*D↑5+3.0634E-12*D↑6
860 S1=A0+A1*M1+A2*M1↑2
870 RETURN
880 END
```

## List of Variables for Program 1

| Variable | Definition |
|---|---|
| G | Gross weight (lbs.) |
| D | Drag count |
| T | Temperature (°C) |
| M | Mach number |
| M1 | Result of lower graph, Figure B1 |
| I | Guidelines, numbered top to bottom consecutively |
| S | Transfer Scale calculated as function of I |
| S1 | Transfer Scale calculated as function of D |
| S2 | Transfer Scale calculated for upper guideline |
| S3 | Transfer Scale calculated for lower guideline |
| I1 | Relative Transfer Scale location between guidelines |
| R,R3 | Reference number |
| R1 | Even reference number below actual reference number |
| R2 | Even reference number above actual reference number |
| J | Integer counter |
| N | Result of lower graph, Figure B3 |
| N1 | Result of lower graph, Figure B3 for R1 |
| N2 | Result of lower graph, Figure B3 for R2 |
| N4 | Result of lower graph, Figure B4 |
| A0,B0, A1,B1 | Coefficients |
| A2,B2, B3,B4 | Coefficients |
| P | Pounds of fuel per nautical mile |
| F | Fuel flow |

# Program 2

```
1 REM  THIS PROGRAM CALCULATES THE TAKEOFF DISTANCE REQUIRED FOR AN A-7E
2 REM  IT IS DEPENDENT ON 9 VARIABLES --
3 REM  GROSS WEIGHT,RNWY ALTITUDE,TEMP,DRAG COUNT,RELATIVE HUMIDITY,WINDS
4 REM  RNWY SLOPE,CENTER OF GRAVITY LOCATION,FLAPS, AND DOUBLE DATUM STATUS
9 PRINT "INPUT ALT,TEMP,DC,GW"
10 INPUT A,B,D,G
11 I=50
12 L=10
13 N=1
14 P=27
20 R=25
100 B0=13.086-0.00017113*A-2.0655E-07*A↑2+3.6861E-11*A↑3
101 B0=B0-2.4156E-15*A↑4
110 B1=-0.045635-7.8931E-06*A+3.7545E-09*A↑2
111 B1=B1-9.7088E-13*A↑3+6.997E-17*A↑4
120 B2=-0.001317-8.2558E-07*A+4.0739E-10*A↑2
121 B2=B2-8.548E-14*A↑3+5.4964E-18*A↑4
130 B3=-1.9097E-05+1.3671E-08*A-9.4694E-12*A↑2+2.0434E-15*A↑3
140 B3=B3-1.4617E-19*A↑4
150 C=B0+B1*B+B2*B↑2+B3*B↑3
160 IF D=1 THEN 190
170 E=0.54178+0.65876*C
180 GOTO 200
190 E=1.9773+0.56598*C
200 G0=-4.8896E+05+8.4974E+01*G-5.7856E-03*G↑2+1.9373E-07*G↑3-3.1744E-12*G↑4
210 G0=G0+2.0446E-17*G↑5
220 G1=5.8621E+04-1.0146E+01*G+6.8807E-04*G↑2-9.292E-08*G↑3+3.7387E-13*G↑4
230 G1=G1-2.3964E-18*G↑5
240 H=G0+G1*E
250 J=0
260 IF I<40 THEN 280
270 J=(I-40)/1000
280 K=H*J+H
285 IF L=0 THEN 340
290 L0=6.7124E+01+8.9509E-01*K+2.3306E-05*K↑2-1.6254E-09*K↑3+3.3728E-14*K↑4
300 L1=-9.0995-1.0856E-02*K+2.1754E-07*K↑2-2.5327E-11*K↑3+1.197E-15*K↑4
310 L2=1.4782E-01-2.1666E-06*K+3.4274E-09*K↑2-2.7817E-13*K↑3+9.3077E-18*K↑4
320 M=L0+L1*L+L2*L↑2
330 GOTO 350
340 M=K
350 X0=4.5704E+01+9.3429E-01*M+2.2265E-05*M↑2-2.338E-09*M↑3+7.941E-14*M↑4
360 X1=7.9472+1.4914E-02*M+9.0708E-06*M↑2-7.1235E-10*M↑3+3.0684E-14*M↑4
370 X2=5.3616-8.5136E-03*M+3.5914E-06*M↑2-4.5932E-10*M↑3+1.9889E-14*M↑4
380 X=X0+X1*N+X2*N↑2
390 Q0=2.6042E+03-2.1694*X+1.0915E-03*X↑2-1.1119E-07*X↑3+3.662E-12*X↑4
400 Q1=-1.7573E+02+2.2601E-01*X-7.5225E-05*X↑2+7.7018E-09*X↑3-2.5437E-13*X↑4
410 Q2=2.8549-4.0102E-03*X+1.2832E-06*X↑2-1.3234E-10*X↑3+4.3908E-15*X↑4
420 Q=Q0+Q1*P+Q2*P↑2
430 S0=-4.0079E+02+1.5801*Q-2.0254E-04*Q↑2+2.4111E-08*Q↑3-8.6737E-13*Q↑4
440 S1=1.6196E+01-2.4333E-02*Q+9.3484E-06*Q↑2-1.2594E-09*Q↑3+4.7522E-14*Q↑4
450 S2=-1.4758E-01+2.359E-04*Q-1.037E-07*Q↑2+1.6016E-11*Q↑3-6.3195E-16*Q↑4
460 S=S0+S1*R+S2*R↑2
470 S=INT(S)
479 PRINT "         FOR"
480 PRINT "GW="G"  ALT="A"  TEMP="B"  DC="D"RH="I"HDWD="L
482 PRINT "RNWY SLP="N"%   CEN GRAV="P"FLAPS="R
483 PRINT
530 PRINT "TAKEOFF ROLL DIST="S
531 GOTO 9
532 END
```

## List of Variables for Program 2

| Variable | Definition |
|---|---|
| A | Runway Altitude (feet) |
| B | Temperature (°C) |
| D | Double datum status (1 indicates "with") |
| G | Gross weight (lbs.) |
| I | Relative humidity (%) |
| L | Headwind (kts.) |
| N | Runway slope (%) |
| P | Center of gravity (%) |
| R | Flap position (degrees) |
| C | Result of upper graph, Figure B5 |
| E | Takeoff factor |
| H | Unadjusted ground roll distance, Figure B6 |
| J | Adjustment factor due to relative humidity |
| K | Ground roll distance (GRD) adjusted for relative humidity |
| M | GRD adjusted for wind |
| X | GRD adjusted for runway slope |
| Q | GRD adjusted for the center of gravity location |
| S | True GRD (also adjusted for flap position) |
| B0,G0,L0, X0,Q0 | Coefficients |
| B1,G1,L1, X1,Q1 | Coefficients |
| B2,G2,L2, X2,Q2 | Coefficients |
| B3,S0, S1,S2 | Coefficients |

# Program 3

```
1 REM  THIS PROGRAM CALCULATES THE A-7E MAXIMUM RANGE´AIRSPEED AND
2 REM  TIME OF FLIGHT AND IS DEPENDENT ON  6 VARIABLES --
3 REM  GROSS WEIGHT,ALTITUDE,DRAG COUNT,TEMPERATURE,WINDS, AND DISTANCE
9 PRINT "INPUT GW,ALT,DC,TEMP(*C),HDWD,DISTANCE"
10 INPUT G,H,D,T,L,D1
30 G=G/1000
40 H=H/1000
50 A0=-1+5.0794E-03*H-1.3968E-03*H↑2-3.4912E-06*H↑3+7.9365E-08*H↑4
60 A1=0.05+0.0015159*H+1.123E-04*H↑2-3.4921E-06*H↑3+7.9365E-08*H↑4
70 N=A0+A1*G
80 B0=0.47803-0.0013417*D+6.2287E-06*D↑2-1.6261E-08*D↑3+1.6438E-11*D↑4
85 B1=0.08217+4.1209E-04*D-4.5577E-06*D↑2+1.6777E-08*D↑3-2.001E-11*D↑4
90 B2=4.2143E-04-9.4397E-05*D+1.2646E-06*D↑2-4.8537E-09*D↑3+5.7222E-12*D↑4
95 B3=-6.6767E-04+8.4671E-06*D-1.0501E-07*D↑2+3.6382E-10*D↑3-3.7828E-13*D↑4
100 M=B0+B1*N+B2*N↑2+B3*N↑3
110 M=M-(((60-T)*2*M)/(10*120))
120 V=710*(M-0.14)+100-L
130 T1=D1/V
135 V=INT(V)
140 PRINT
150 PRINT "FOR"
160 PRINT "GW="G"  ALT="H"  DC="D"TEMP="T"  HDWD="L"DIST="D1
161 PRINT
162 PRINT "GROUND SPEED="V"    TIME OF FLIGHT="T1
170 END
```

## List of Variables for Program 3

| Variable | Definition |
|---|---|
| G | Gross weight (lbs.) |
| H | Altitude (ft.) |
| D | Drag count |
| T | Temperature (°C) |
| L | Headwind (kts.) |
| D1 | Distance to fly |
| N | Result of first chart, Figure B8 |
| M | Cruise Mach number (adjusted and unadjusted for T) |
| V | Ground speed (kts.) |
| T1 | Time of flight |
| A0,B0 | Coefficients |
| A1,B1 | Coefficients |
| B3 | Coefficient |

## Program 4

```
10 REM       THIS PROGRAM CALCULATES  FUEL REQUIRED FOR MAX RANGE AT CONSTANT
11 REM  ALTITUDE FOR AN A-7E AND IS DEPENDENT ON 5 VARIABLES --
12 REM  GROSS WEIGHT,ALTITUDE,DRAG COUNT,TRUE AIRSPEED, AND TIME(MINUTES)
20 PRINT "ENTER GROSS WT,ALT,DRAG CT,TAS,TIME(MINUTES)"
21 PRINT
22 PRINT
30 INPUT G,A,D,V,T
35 PRINT "GROSS WT="G
36 PRINT "ALTITUDE="A
37 PRINT "DRAG COUNT="D
38 PRINT "TRUE AIRSPEED="V
39 PRINT "TIME OF FLIGHT="T
40 G=G/1000
50 A=A/1000
60 B0=4.54-0.16444*A+0.0033932*A↑2-1.0283E-04*A↑3+1.926E-06*A↑4-1.3757E-08*A↑5
70 B1=-3.6664E-03*A+8.9338E-04*A↑2-5.5939E-05*A↑3+1.4593E-06*A↑4-1.3281E-08*A↑5
80 B2=6E-04+1.1203E-04*A-2.3358E-05*A↑2+1.4536E-06*A↑3-3.7144E-08*A↑4
85 B2=B2+3.3334E-10*A↑5
90 N=B0+B1*G+B2*G↑2
100 A0=-2.5399E-03*D+9.7299E-05*D↑2-2.3516E-07*D↑3+1.4251E-10*D↑4
110 A1=2+4.2388E-03*D+1.2326E-05*D↑2-1.0298E-07*D↑3+1.7277E-10*D↑4
120 L=A0+A1*N
130 F=L*V
140 R=F*T/60
141 L=(INT(L*1000))/1000
142 F=INT(F)
143 R=INT(R)
147 PRINT
148 PRINT
150 PRINT "LBFUEL/NM="L"FUEL FLOW="F
155 PRINT "FUEL REQUIRED="R
156 PRINT
157 PRINT
160 GOTO 20
170 END
```

## List of Variables for Program 4

| Variable | Definition |
|---|---|
| G | Gross weight (lbs.) |
| A | Altitude (ft.) |
| D | Drag count |
| V | True airspeed (kts.) |
| T | Time of flight (minutes) |
| N | Result of first chart, Figure B9 |
| L | Pounds of fuel per nautical mile |
| F | Fuel flow |
| R | Fuel required |
| B0,A0 | Coefficients |
| B1,A1 | Coefficients |
| B2 | Coefficient |

# Program 5

```
1 REM  THIS PROGRAM CALCULATES THE CLIMB AIRSPEED OF AN A-7E
2 REM  (INDICATED AIRSPEED BELOW 20,000')
3 REM  (MACH NUMBER ABOVE 20,000')
10 D=0
12 PRINT "CLIMB AIRSPEED SCHEDULE"
15 PRINT "DRAG CT      CLIMB AIRSPEED   CLIMB MACH"
16 PRINT "             (IAS TO 20000')  (ABOVE 20000')"
20 S=403.56-0.79075*D+0.0011382*D↑2-4.1018E-07*D↑3
21 S=INT(S)
30 M=0.86-2.1634E-03*D+7.6582E-05*D↑2-1.1344E-06*D↑3+7.2125E-09*D↑4-2.3035E-11*D   ↑5
40 M=M+3.6588E-14*D↑6-2.3062E-17*D↑7
42 M=M*1000
44 M=INT(M)
46 M=M/1000
55 PRINT D,S,M
60 D=D+30
70 IF D<310 THEN 20
80 END
```

List of Variables for Program 5

| Variable | Definition |
| --- | --- |
| D | Drag count |
| M | Mach number |
| S | Calibrated airspeed (kts.) |

Program 6

```
400 REM  THIS PROGRAM CALCULATES THE TAKEOFF AIRSPEED OF AN A-7E
401 REM  UNDER VARYING  GROSS WEIGHTS, FLAP POSITIONS,
402 REM  AND CENTER OF GRAVITY LOCATIONS
498 R=20
499 P=20
500 G=20000
501 PRINT "FOR GROSS WEIGHT="G
502 PRINT
503 PRINT
504 PRINT "FLAPS              CG         TAKEOFF AIRSPEED"
530 U1=5.4023E+01+3.4787E-03*G-1.9475E-08*G↑2
540 U=U1+(26-P)/2
550 V0=-1.9171E+03+6.1604E+01*U-7.0348E-01*U↑2+3.5661E-03*U↑3-6.6578E-06*U↑4
560 V1=7.6824E+01-2.4517*U+2.8779E-02*U↑2-1.4753E-04*U↑3+2.7872E-07*U↑4
570 V2=-7.2239E-01+2.3415E-02*U-2.798E-04*U↑2+1.4596E-06*U↑3-2.807E-09*U↑4
580 V3=V0+V1*R+V2*R↑2
590 V4=INT(V3)
600 PRINT R,P,V4
610 R=R+5
620 IF R>40 THEN 630
625 GOTO 530
630 P=P+3
631 R=20
635 IF P>35 THEN 650
640 GOTO 530
650 G=G+3000
651 R=20
652 P=20
655 PRINT
656 PRINT
657 PRINT
660 PRINT "FOR GROSS WEIGHT="G
662 PRINT
663 PRINT
669 IF G>42000 THEN 710
670 GOTO 530
710 END
```

## List of Variables for Program 6

| Variable | Definition |
|---|---|
| R | Flap position (degrees) |
| P | Center of gravity (%) |
| G | Gross weight (lbs.) |
| U1 | Unadjusted takeoff airspeed |
| U | Takeoff airspeed adjusted for center of gravity |
| V4 | Actual takeoff airspeed (adjusted for flap position) |
| V0,V1, V2,V3 | Coefficients |

# Program 7

```
1 REM  THIS PROGRAM CALCULATES THE MAXIMUM REFUSAL SPEED
2 REM  FOR AN A-7E USING ANTI-SKID
3 REM  IT  IS DEPENDENT ON 5 VARIABLES --
4 REM  GROSS WEIGHT,TEMP,RNWY LENGTH,RNWY ALTITUDE, AND DOUBLE DATUM STATUS
9 PRINT "INPUT ALT,TEMP,RNWY LTH,GW,DOUBLE DATUM"
10 INPUT A,B,L,G,D
15 G=G/1000
20 L=L/1000
70 PRINT "ALTITUDE="A
71 PRINT "TEMP="B
72 PRINT "RNWY LTH="L*1000
73 PRINT "GROSS WT="G*1000
75 PRINT "DD="D
100 B0=13.086-0.00017113*A-2.0655E-07*A↑2+3.6861E-11*A↑3
101 B0=B0-2.4156E-15*A↑4
110 B1=-0.045635-7.8931E-06*A+3.7545E-09*A↑2
111 B1=B1-9.7088E-13*A↑3+6.997E-17*A↑4
120 B2=-0.001317-8.2558E-07*A+4.0739E-10*A↑2
121 B2=B2-8.548E-14*A↑3+5.4964E-18*A↑4
130 B3=-1.9097E-05+1.3671E-08*A-9.4694E-12*A↑2+2.0434E-15*A↑3
140 B3=B3-1.4617E-19*A↑4
150 C=B0+B1*B+B2*B↑2+B3*B↑3
160 IF D=1 THEN 190
170 E=0.54178+0.65876*C
180 GOTO 200
190 E=1.9773+0.56598*C
200 B0=-43.01+6.761*G-0.35159*G↑2+0.0080545*G↑3-6.7769E-05*G↑4
210 B1=26.312-3.8382*G+0.20326*G↑2-0.0047022*G↑3+3.994E-05*G↑4
220 B2=-4.9639+0.72723*G-0.038721*G↑2+8.985E-04*G↑3-7.638E-06*G↑4
230 B3=0.30288-0.044855*G+0.0023921*G↑2-5.5549E-05*G↑3+4.7217E-07*G↑4
240 R=B0+B1*E+B2*E↑2+B3*E↑3
250 B0=-11.412+62.185*L-9.0037*L↑2+0.64921*L↑3-0.017455*L↑4
260 B1=-0.2811-4.2012*L+0.70377*L↑2-0.058693*L↑3+0.0017461*L↑4
270 M=B0+B1*R
271 M=INT(M)
272 PRINT
275 PRINT "   TAKEOFF FACTOR   ="E
276 PRINT
280 PRINT "MAX REFUSAL SPEED =  ",M
281 PRINT
290 GOTO 9
300 END
```

## List of Variables for Program 7

| Variable | Definition |
|---|---|
| A | Runway Altitude (ft.) |
| B | Temperature (°C) |
| L | Runway length (ft.) |
| G | Gross weight (lbs.) |
| D | Double datum status (1 indicates "with") |
| C | Result of upper chart, Figure B5 |
| E | Takeoff factor |
| R | Result of first chart, Figure B12 |
| M | Maximum refusal speed (kts.) |
| B0,B1, B2,B3 | Coefficients |

Program 8

```
1 REM  THIS PROGRAM CALCULATES THE OPTIMUM ENDURANCE ALTITUDE
2 REM  OF AN A-7E AT VARYING GROSS WEIGHTS AND DRAG COUNTS
4 DIM B[3]
5 G=19
6 D=0
10 PRINT "OPTIMUM ENDURANCE ALT "
20 PRINT "GROSS WT     DRAG CT              OPT END ALT"
50 G=G+3
80 B[3]=55.333+0.073076*D-9.7836E-04*D↑2+3.5015E-06*D↑3-3.9782E-09*D↑4
90 B[1]=-1.1-8.0597E-03*D+8.0097E-05*D↑2-2.8836E-07*D↑3+3.3032E-10*D↑4
100 B[2]=6.6667E-03+1.2541E-04*D-1.4039E-06*D↑2+5.2032E-09*D↑3-6.0218E-12*D↑4
110 H=B[3]+B[1]*G+B[2]*G↑2
115 Z=INT(H*1000)
118 X=G*1000
119 PRINT X,D,Z
120 D=D+30
121 IF D<310 THEN 80
122 D=0
123 IF G<45 THEN 50
140 END
```

## List of Variables for Program 8

| Variable | Definition |
|---|---|
| G | Gross weight (lbs. times 1000) |
| D | Drag count |
| H | Optimum endurance altitude (ft.) |
| Z | Optimum endurance altitude ( integer format) |
| X | Gross weight (lbs.) |
| B1,B2,B3 | Coefficients |

## Program 9

```
1 REM  THIS PROGRAM CALCULATES THE CRUISE CEILING OF AN A-7E
2 REM  UNDER VARYING GROSS WEIGHTS AND DRAG COUNTS
4 DIM B[4]
5 G=19
6 D=0
10 PRINT "CRUISE CEILING"
20 PRINT "GROSS WT    DRAG CT             CRUISE CEILING"
50 G=G+3
80 B[4]=85.118-0.29117*D+0.0030434*D↑2-1.2851E-05*D↑3+1.6621E-08*D↑4
90 B[1]=-2.7877+0.025635*D-3.3063E-04*D↑2+1.4162E-06*D↑3-1.8343E-09*D↑4
100 B[2]=0.063327-8.5289E-04*D+1.0814E-05*D↑2-4.6514E-08*D↑3+6.0606E-11*D↑4
105 B[3]=-6.0468E-04+9.0826E-06*D-1.143E-07*D↑2+4.9304E-10*D↑3-6.4567E-13*D↑4
110 H=B[4]+B[1]*G+B[2]*G↑2+B[3]*G↑3
115 Z=INT(H*1000)
118 X=G*1000
119 PRINT X,D,Z
120 D=D+30
121 IF D<310 THEN 80
122 D=0
123 IF G<45 THEN 50
140 END
```

## List of Variables for Program 9

| Variable | Definition |
| --- | --- |
| G | Gross weight (lbs. times 1000) |
| D | Drag count |
| H | Cruise ceiling (ft.) |
| Z | Cruise ceiling (integer format) |
| X | Gross weight (lbs.) |
| B1,B2,<br>B3,B4 | Coefficients |

## APPENDIX E

## TI-59 Programs and User Information

USER INFORMATION FOR PROGRAM 1

Program: Low Level Cruise Performance

Number of Steps: 1386

Computation Time: 90-110 seconds

| STEP | ENTER | PRESS KEY | DISPLAY |
|---|---|---|---|
| 1 | gross weight (lbs.) | A | gross weight/1000 |
| 2 | drag count | C | drag count |
| 3 | mach number | D | mach number |
| 4 | temperature (°C) | E | Transfer Scale |
| 5 | --- | R/S | Unusable number |
| 6 | read in cards 3 & 4 | - | --- |
| 7 | drag count | C | Transfer Scale |
| 8 | mach number | D | mach number |
| 9 | temperature (°C) | E | lb.fuel/nautical mile |
| 0 | --- | R/S | fuel flow |

| | | |
|---|---|---|
| 000 | 76 | LBL |
| 001 | 11 | A |
| 002 | 55 | ÷ |
| 003 | 01 | 1 |
| 004 | 00 | 0 |
| 005 | 00 | 0 |
| 006 | 00 | 0 |
| 007 | 95 | = |
| 008 | 42 | STO |
| 009 | 00 | 00 |
| 010 | 91 | R/S |
| 011 | 76 | LBL |
| 012 | 12 | B |
| 013 | 55 | ÷ |
| 014 | 01 | 1 |
| 015 | 00 | 0 |
| 016 | 00 | 0 |
| 017 | 00 | 0 |
| 018 | 95 | = |
| 019 | 42 | STO |
| 020 | 01 | 01 |
| 021 | 91 | R/S |
| 022 | 76 | LBL |
| 023 | 13 | C |
| 024 | 42 | STO |
| 025 | 02 | 02 |
| 026 | 91 | R/S |
| 027 | 76 | LBL |
| 028 | 14 | D |
| 029 | 42 | STO |
| 030 | 03 | 03 |
| 031 | 91 | R/S |
| 032 | 76 | LBL |
| 033 | 15 | E |
| 034 | 42 | STO |
| 035 | 04 | 04 |
| 036 | 53 | ( |
| 037 | 93 | . |
| 038 | 03 | 3 |
| 039 | 08 | 8 |
| 040 | 08 | 8 |
| 041 | 01 | 1 |
| 042 | 03 | 3 |
| 043 | 85 | + |
| 044 | 93 | . |
| 045 | 00 | 0 |
| 046 | 00 | 0 |
| 047 | 04 | 4 |
| 048 | 02 | 2 |
| 049 | 09 | 9 |
| 050 | 08 | 8 |
| 051 | 01 | 1 |
| 052 | 65 | × |
| 053 | 43 | RCL |
| 054 | 00 | 00 |
| 055 | 95 | = |
| 056 | 42 | STO |
| 057 | 05 | 05 |
| 058 | 25 | CLR |
| 059 | 75 | - |
| 060 | 53 | ( |
| 061 | 02 | 2 |
| 062 | 93 | . |
| 063 | 03 | 3 |
| 064 | 02 | 2 |
| 065 | 08 | 8 |
| 066 | 07 | 7 |
| 067 | 85 | + |
| 068 | 93 | . |
| 069 | 02 | 2 |
| 070 | 06 | 6 |
| 071 | 03 | 3 |
| 072 | 01 | 1 |
| 073 | 06 | 6 |
| 074 | 65 | × |
| 075 | 43 | RCL |
| 076 | 02 | 02 |
| 077 | 75 | - |
| 078 | 93 | . |
| 079 | 00 | 0 |
| 080 | 00 | 0 |
| 081 | 07 | 7 |
| 082 | 03 | 3 |
| 083 | 03 | 3 |
| 084 | 02 | 2 |
| 085 | 07 | 7 |
| 086 | 65 | × |
| 087 | 43 | RCL |
| 088 | 02 | 02 |
| 089 | 33 | $X^2$ |
| 090 | 85 | + |
| 091 | 07 | 7 |
| 092 | 93 | . |
| 093 | 05 | 5 |
| 094 | 01 | 1 |
| 095 | 03 | 3 |
| 096 | 52 | EE |
| 097 | 94 | +/- |
| 098 | 05 | 5 |
| 099 | 65 | × |
| 100 | 43 | RCL |
| 101 | 02 | 02 |
| 102 | 45 | $Y^X$ |
| 103 | 03 | 3 |
| 104 | 75 | - |
| 105 | 03 | 3 |
| 106 | 93 | . |
| 107 | 05 | 5 |
| 108 | 03 | 3 |
| 109 | 09 | 9 |
| 110 | 06 | 6 |
| 111 | 52 | EE |
| 112 | 94 | +/- |
| 113 | 07 | 7 |
| 114 | 65 | × |
| 115 | 43 | RCL |
| 116 | 02 | 02 |
| 117 | 45 | $Y^X$ |
| 118 | 04 | 4 |
| 119 | 85 | + |
| 120 | 07 | 7 |
| 121 | 93 | . |
| 122 | 07 | 7 |
| 123 | 08 | 8 |
| 124 | 52 | EE |
| 125 | 94 | +/- |
| 126 | 01 | 1 |
| 127 | 00 | 0 |
| 128 | 65 | × |
| 129 | 43 | RCL |
| 130 | 02 | 02 |
| 131 | 45 | $Y^X$ |
| 132 | 05 | 5 |
| 133 | 75 | - |
| 134 | 06 | 6 |
| 135 | 93 | . |
| 136 | 04 | 4 |
| 137 | 06 | 6 |
| 138 | 02 | 2 |
| 139 | 04 | 4 |
| 140 | 52 | EE |
| 141 | 94 | +/- |
| 142 | 01 | 1 |
| 143 | 03 | 3 |
| 144 | 65 | × |
| 145 | 43 | RCL |
| 146 | 02 | 02 |
| 147 | 45 | $Y^X$ |
| 148 | 06 | 6 |
| 149 | 54 | ) |

| | | |
|---|---|---|
| 150 | 85 | + |
| 151 | 53 | ( |
| 152 | 04 | 4 |
| 153 | 93 | . |
| 154 | 08 | 8 |
| 155 | 03 | 3 |
| 156 | 05 | 5 |
| 157 | 85 | + |
| 158 | 01 | 1 |
| 159 | 93 | . |
| 160 | 00 | 0 |
| 161 | 09 | 9 |
| 162 | 05 | 5 |
| 163 | 06 | 6 |
| 164 | 65 | × |
| 165 | 43 | RCL |
| 166 | 02 | 02 |
| 167 | 75 | - |
| 168 | 93 | . |
| 169 | 00 | 0 |
| 170 | 03 | 3 |
| 171 | 00 | 0 |
| 172 | 06 | 6 |
| 173 | 05 | 5 |
| 174 | 03 | 3 |
| 175 | 65 | × |
| 176 | 43 | RCL |
| 177 | 02 | 02 |
| 178 | 33 | $X^2$ |
| 179 | 85 | + |
| 180 | 03 | 3 |
| 181 | 93 | . |
| 182 | 01 | 1 |
| 183 | 09 | 9 |
| 184 | 01 | 1 |
| 185 | 02 | 2 |
| 186 | 52 | EE |
| 187 | 94 | +/- |
| 188 | 04 | 4 |
| 189 | 65 | × |
| 190 | 43 | RCL |
| 191 | 02 | 02 |
| 192 | 45 | $Y^x$ |
| 193 | 03 | 3 |
| 194 | 75 | - |
| 195 | 01 | 1 |
| 196 | 93 | . |
| 197 | 05 | 5 |
| 198 | 02 | 2 |
| 199 | 07 | 7 |
| 200 | 06 | 6 |
| 201 | 52 | EE |
| 202 | 94 | +/- |
| 203 | 06 | 6 |
| 204 | 65 | × |
| 205 | 43 | RCL |
| 206 | 02 | 02 |
| 207 | 45 | $Y^x$ |
| 208 | 04 | 4 |
| 209 | 85 | + |
| 210 | 03 | 3 |
| 211 | 93 | . |
| 212 | 04 | 4 |
| 213 | 00 | 0 |
| 214 | 08 | 8 |
| 215 | 52 | EE |
| 216 | 94 | +/- |
| 217 | 09 | 9 |
| 218 | 65 | × |
| 219 | 43 | RCL |
| 220 | 02 | 02 |
| 221 | 45 | $Y^x$ |
| 222 | 05 | 5 |
| 223 | 75 | - |
| 224 | 02 | 2 |
| 225 | 93 | . |
| 226 | 08 | 8 |
| 227 | 06 | 6 |
| 228 | 09 | 9 |
| 229 | 02 | 2 |
| 230 | 52 | EE |
| 231 | 94 | +/- |
| 232 | 01 | 1 |
| 233 | 02 | 2 |
| 234 | 65 | × |
| 235 | 43 | RCL |
| 236 | 02 | 02 |
| 237 | 45 | $Y^x$ |
| 238 | 06 | 6 |
| 239 | 54 | ) |
| 240 | 65 | × |
| 241 | 43 | RCL |
| 242 | 05 | 05 |
| 243 | 85 | + |
| 244 | 53 | ( |
| 245 | 01 | 1 |
| 246 | 00 | 0 |
| 247 | 93 | . |
| 248 | 02 | 2 |
| 249 | 08 | 8 |
| 250 | 04 | 4 |
| 251 | 75 | - |
| 252 | 01 | 1 |
| 253 | 93 | . |
| 254 | 00 | 0 |
| 255 | 07 | 7 |
| 256 | 01 | 1 |
| 257 | 09 | 9 |
| 258 | 65 | × |
| 259 | 43 | RCL |
| 260 | 02 | 02 |
| 261 | 85 | + |
| 262 | 93 | . |
| 263 | 00 | 0 |
| 264 | 03 | 3 |
| 265 | 01 | 1 |
| 266 | 00 | 0 |
| 267 | 09 | 9 |
| 268 | 04 | 4 |
| 269 | 65 | × |
| 270 | 43 | RCL |
| 271 | 02 | 02 |
| 272 | 33 | $X^2$ |
| 273 | 75 | - |
| 274 | 03 | 3 |
| 275 | 93 | . |
| 276 | 02 | 2 |
| 277 | 08 | 8 |
| 278 | 07 | 7 |
| 279 | 08 | 8 |
| 280 | 52 | EE |
| 281 | 94 | +/- |
| 282 | 04 | 4 |
| 283 | 65 | × |
| 284 | 43 | RCL |
| 285 | 02 | 02 |
| 286 | 45 | $Y^x$ |
| 287 | 03 | 3 |
| 288 | 85 | + |
| 289 | 01 | 1 |
| 290 | 93 | . |
| 291 | 05 | 5 |
| 292 | 09 | 9 |
| 293 | 05 | 5 |
| 294 | 52 | EE |
| 295 | 94 | +/- |
| 296 | 06 | 6 |
| 297 | 65 | × |
| 298 | 43 | RCL |
| 299 | 02 | 02 |

```
300  45  YX
301  04  4
302  75  -
303  03  3
304  93  .
305  06  6
306  00  0
307  00  0
308  09  9
309  52  EE
310  94  +/-
311  09  9
312  65  X
313  43  RCL
314  02  02
315  45  YX
316  05  5
317  85  +
318  03  3
319  93  .
320  00  0
321  06  6
322  03  3
323  04  4
324  52  EE
325  94  +/-
326  01  1
327  02  2
328  65  X
329  43  RCL
330  02  02
331  45  YX
332  06  6
333  54  )
334  65  X
335  43  RCL
336  05  05
337  33  X²
338  95  =
339  42  STO
340  06  06
341  25  CLR
342  42  STO
343  07  07
344  71  SBR
345  04  04
346  43  43
347  42  STO
348  08  08
349  32  X:T
350  43  RCL
351  06  06
352  22  INV
353  77  GE
354  03  03
355  88  88
356  01  1
357  42  STO
358  07  07
359  71  SBR
360  04  04
361  43  43
362  42  STO
363  09  09
364  32  X:T
365  43  RCL
366  06  06
367  22  INV
368  77  GE
369  04  04
370  01  01
371  43  RCL
372  09  09
373  42  STO
374  08  08
375  43  RCL
376  07  07
377  85  +
378  01  1
379  95  =
380  42  STO
381  07  07
382  71  SBR
383  04  04
384  43  43
385  61  GTO
386  03  03
387  62  62
388  43  RCL
389  03  03
390  42  STO
391  05  05
392  71  SBR
393  04  04
394  43  43
395  42  STO
396  05  05
397  61  GTO
398  06  06
399  68  68
400  00  0
401  53  (
402  43  RCL
403  06  06
404  75  -
405  43  RCL
406  08  08
407  54  )
408  55  ÷
409  53  (
410  43  RCL
411  09  09
412  75  -
413  43  RCL
414  08  08
415  54  )
416  95  =
417  42  STO
418  00  00
419  43  RCL
420  03  03
421  42  STO
422  05  05
423  43  RCL
424  07  07
425  75  -
426  01  1
427  85  +
428  43  RCL
429  00  00
430  95  =
431  42  STO
432  07  07
433  71  SBR
434  04  04
435  43  43
436  42  STO
437  05  05
438  61  GTO
439  06  06
440  68  68
441  00  0
442  00  0
443  02  2
444  02  2
445  93  .
446  08  8
447  01  1
448  09  9
449  75  -
```

| | | |
|---|---|---|
| 450 | 03 | 3 |
| 451 | 01 | 1 |
| 452 | 93 | . |
| 453 | 07 | 7 |
| 454 | 03 | 3 |
| 455 | 05 | 5 |
| 456 | 65 | × |
| 457 | 43 | RCL |
| 458 | 07 | 07 |
| 459 | 85 | + |
| 460 | 04 | 4 |
| 461 | 01 | 1 |
| 462 | 93 | . |
| 463 | 03 | 3 |
| 464 | 03 | 3 |
| 465 | 65 | × |
| 466 | 43 | RCL |
| 467 | 07 | 07 |
| 468 | 33 | $X^2$ |
| 469 | 75 | - |
| 470 | 05 | 5 |
| 471 | 93 | . |
| 472 | 00 | 0 |
| 473 | 09 | 9 |
| 474 | 05 | 5 |
| 475 | 03 | 3 |
| 476 | 65 | × |
| 477 | 43 | RCL |
| 478 | 07 | 07 |
| 479 | 45 | $Y^x$ |
| 480 | 03 | 3 |
| 481 | 75 | - |
| 482 | 53 | ( |
| 483 | 01 | 1 |
| 484 | 05 | 5 |
| 485 | 04 | 4 |
| 486 | 93 | . |
| 487 | 09 | 9 |
| 488 | 08 | 8 |
| 489 | 75 | - |
| 490 | 02 | 2 |
| 491 | 01 | 1 |
| 492 | 07 | 7 |
| 493 | 93 | . |
| 494 | 05 | 5 |
| 495 | 01 | 1 |
| 496 | 65 | × |
| 497 | 43 | RCL |
| 498 | 07 | 07 |
| 499 | 85 | + |
| 500 | 02 | 2 |
| 501 | 06 | 6 |
| 502 | 01 | 1 |
| 503 | 93 | . |
| 504 | 07 | 7 |
| 505 | 03 | 3 |
| 506 | 65 | × |
| 507 | 43 | RCL |
| 508 | 07 | 07 |
| 509 | 33 | $X^2$ |
| 510 | 75 | - |
| 511 | 03 | 3 |
| 512 | 05 | 5 |
| 513 | 93 | . |
| 514 | 09 | 9 |
| 515 | 00 | 0 |
| 516 | 05 | 5 |
| 517 | 65 | × |
| 518 | 43 | RCL |
| 519 | 07 | 07 |
| 520 | 45 | $Y^x$ |
| 521 | 03 | 3 |
| 522 | 54 | ) |
| 523 | 65 | × |
| 524 | 43 | RCL |
| 525 | 05 | 05 |
| 526 | 85 | + |
| 527 | 53 | ( |
| 528 | 04 | 4 |
| 529 | 00 | 0 |
| 530 | 05 | 5 |
| 531 | 93 | . |
| 532 | 00 | 0 |
| 533 | 08 | 8 |
| 534 | 75 | - |
| 535 | 05 | 5 |
| 536 | 02 | 2 |
| 537 | 05 | 5 |
| 538 | 93 | . |
| 539 | 05 | 5 |
| 540 | 06 | 6 |
| 541 | 65 | × |
| 542 | 43 | RCL |
| 543 | 07 | 07 |
| 544 | 85 | + |
| 545 | 06 | 6 |
| 546 | 00 | 0 |
| 547 | 07 | 7 |
| 548 | 93 | . |
| 549 | 04 | 4 |
| 550 | 09 | 9 |
| 551 | 65 | × |
| 552 | 43 | RCL |
| 553 | 07 | 07 |
| 554 | 33 | $X^2$ |
| 555 | 75 | - |
| 556 | 08 | 8 |
| 557 | 08 | 8 |
| 558 | 93 | . |
| 559 | 07 | 7 |
| 560 | 03 | 3 |
| 561 | 07 | 7 |
| 562 | 65 | × |
| 563 | 43 | RCL |
| 564 | 07 | 07 |
| 565 | 45 | $Y^x$ |
| 566 | 03 | 3 |
| 567 | 54 | ) |
| 568 | 65 | × |
| 569 | 43 | RCL |
| 570 | 05 | 05 |
| 571 | 33 | $X^2$ |
| 572 | 75 | - |
| 573 | 53 | ( |
| 574 | 04 | 4 |
| 575 | 04 | 4 |
| 576 | 05 | 5 |
| 577 | 93 | . |
| 578 | 06 | 6 |
| 579 | 02 | 2 |
| 580 | 75 | - |
| 581 | 05 | 5 |
| 582 | 04 | 4 |
| 583 | 02 | 2 |
| 584 | 93 | . |
| 585 | 09 | 9 |
| 586 | 08 | 8 |
| 587 | 65 | × |
| 588 | 43 | RCL |
| 589 | 07 | 07 |
| 590 | 85 | + |
| 591 | 06 | 6 |
| 592 | 01 | 1 |
| 593 | 01 | 1 |
| 594 | 93 | . |
| 595 | 05 | 5 |
| 596 | 05 | 5 |
| 597 | 65 | × |
| 598 | 43 | RCL |
| 599 | 07 | 07 |

```
600  33  X^2
601  75  -
602  09  9
603  02  2
604  93  .
605  08  8
606  09  9
607  04  4
608  65  x
609  43  RCL
610  07  07
611  45  Y^X
612  03  3
613  54  )
614  65  x
615  43  RCL
616  05  05
617  45  Y^X
618  03  3
619  85  +
620  53  (
621  01  1
622  08  8
623  04  4
624  93  .
625  07  7
626  08  8
627  75  -
628  02  2
629  00  0
630  04  4
631  93  .
632  04  4
633  02  2
634  65  x
635  43  RCL
636  07  07
637  85  +
638  02  2
639  02  2
640  05  5
641  93  .
642  08  8
643  09  9
644  65  x
645  43  RCL
646  07  07
647  33  X^2
648  75  -
649  03  3
```

```
650  05  5
651  93  .
652  01  1
653  08  8
654  09  9
655  65  x
656  43  RCL
657  07  07
658  45  Y^X
659  03  3
660  54  )
661  65  x
662  43  RCL
663  05  05
664  45  Y^X
665  04  4
666  95  =
667  92  RTN
668  91  R/S
669  32  X:T
670  91  R/S
671  00  0
000  76  LBL
001  13  C
002  42  STO
003  02  02
004  32  X:T
005  42  STO
006  05  05
007  91  R/S
008  76  LBL
009  14  D
010  42  STO
011  03  03
012  91  R/S
013  76  LBL
014  15  E
015  42  STO
016  04  04
017  25  CLR
018  00  0
019  00  0
020  00  0
021  00  0
022  00  0
023  00  0
024  00  0
025  00  0
026  00  0
```

```
027  00  0
028  00  0
029  00  0
030  00  0
031  00  0
032  00  0
033  00  0
034  00  0
035  00  0
036  53  (
037  04  4
038  93  .
039  03  3
040  07  7
041  03  3
042  02  2
043  52  EE
044  94  +/-
045  03  3
046  85  +
047  93  .
048  00  0
049  02  2
050  07  7
051  07  7
052  04  4
053  03  3
054  65  x
055  43  RCL
056  02  02
057  54  )
058  65  x
059  43  RCL
060  03  03
061  33  X^2
062  95  =
063  65  x
064  02  2
065  85  +
066  43  RCL
067  05  05
068  95  =
069  42  STO
070  06  06
071  55  ÷
072  02  2
073  95  =
074  59  INT
075  75  -
076  43  RCL
```

```
077  06  06
078  55  ÷
079  02  2
080  95  =
081  50  I×I
082  42  STO
083  07  07
084  43  RCL
085  06  06
086  55  ÷
087  02  2
088  95  =
089  59  INT
090  65  ×
091  02  2
092  95  =
093  42  STO
094  09  09
095  71  SBR
096  01  01
097  33  33
098  42  STO
099  08  08
100  43  RCL
101  06  06
102  55  ÷
103  02  2
104  95  =
105  59  INT
106  65  ×
107  02  2
108  95  =
109  85  +
110  02  2
111  95  =
112  42  STO
113  09  09
114  71  SBR
115  01  01
116  33  33
117  75  -
118  43  RCL
119  08  08
120  95  =
121  65  ×
122  43  RCL
123  07  07
124  85  +
125  43  RCL
126  08  08
127  95  =
128  42  STO
129  07  07
130  61  GTO
131  06  06
132  02  02
133  05  5
134  93  .
135  06  6
136  02  2
137  05  5
138  03  3
139  75  -
140  01  1
141  93  .
142  09  9
143  08  8
144  09  9
145  65  ×
146  43  RCL
147  09  09
148  85  +
149  03  3
150  93  .
151  00  0
152  02  2
153  05  5
154  02  2
155  65  ×
156  43  RCL
157  09  09
158  33  X²
159  75  -
160  01  1
161  93  .
162  00  0
163  07  7
164  06  6
165  01  1
166  65  ×
167  43  RCL
168  09  09
169  45  Yˣ
170  03  3
171  85  +
172  93  .
173  01  1
174  07  7
175  06  6
176  07  7
177  06  6
178  65  ×
179  43  RCL
180  09  09
181  45  Yˣ
182  04  4
183  75  -
184  93  .
185  00  0
186  01  1
187  03  3
188  00  0
189  09  9
190  05  5
191  65  ×
192  43  RCL
193  09  09
194  45  Yˣ
195  05  5
196  85  +
197  03  3
198  93  .
199  05  5
200  02  2
201  06  6
202  52  EE
203  94  +/-
204  04  4
205  65  ×
206  43  RCL
207  09  09
208  45  Yˣ
209  06  6
210  85  +
211  53  (
212  02  2
213  00  0
214  05  5
215  93  .
216  03  3
217  00  0
218  01  1
219  02  2
220  75  -
221  02  2
222  04  4
223  08  8
224  93  .
225  09  9
226  03  3
```

| | | |
|---|---|---|
| 227 | 01 | 1 |
| 228 | 07 | 7 |
| 229 | 65 | × |
| 230 | 43 | RCL |
| 231 | 09 | 09 |
| 232 | 85 | + |
| 233 | 09 | 9 |
| 234 | 01 | 1 |
| 235 | 93 | . |
| 236 | 06 | 6 |
| 237 | 06 | 6 |
| 238 | 03 | 3 |
| 239 | 05 | 5 |
| 240 | 05 | 5 |
| 241 | 65 | × |
| 242 | 43 | RCL |
| 243 | 09 | 09 |
| 244 | 33 | X² |
| 245 | 75 | - |
| 246 | 01 | 1 |
| 247 | 05 | 5 |
| 248 | 93 | . |
| 249 | 05 | 5 |
| 250 | 05 | 5 |
| 251 | 02 | 2 |
| 252 | 01 | 1 |
| 253 | 08 | 8 |
| 254 | 65 | × |
| 255 | 43 | RCL |
| 256 | 09 | 09 |
| 257 | 45 | Y× |
| 258 | 03 | 3 |
| 259 | 85 | + |
| 260 | 01 | 1 |
| 261 | 93 | . |
| 262 | 02 | 2 |
| 263 | 02 | 2 |
| 264 | 04 | 4 |
| 265 | 04 | 4 |
| 266 | 03 | 3 |
| 267 | 02 | 2 |
| 268 | 65 | × |
| 269 | 43 | RCL |
| 270 | 09 | 09 |
| 271 | 45 | Y× |
| 272 | 04 | 4 |
| 273 | 75 | - |
| 274 | 93 | . |
| 275 | 00 | 0 |
| 276 | 03 | 3 |
| 277 | 09 | 9 |
| 278 | 05 | 5 |
| 279 | 03 | 3 |
| 280 | 03 | 3 |
| 281 | 03 | 3 |
| 282 | 65 | × |
| 283 | 43 | RCL |
| 284 | 09 | 09 |
| 285 | 45 | Y× |
| 286 | 05 | 5 |
| 287 | 85 | + |
| 288 | 02 | 2 |
| 289 | 93 | . |
| 290 | 08 | 8 |
| 291 | 09 | 9 |
| 292 | 06 | 6 |
| 293 | 03 | 3 |
| 294 | 08 | 8 |
| 295 | 05 | 5 |
| 296 | 52 | EE |
| 297 | 94 | +/- |
| 298 | 04 | 4 |
| 299 | 65 | × |
| 300 | 43 | RCL |
| 301 | 09 | 09 |
| 302 | 45 | Y× |
| 303 | 06 | 6 |
| 304 | 54 | ) |
| 305 | 65 | × |
| 306 | 43 | RCL |
| 307 | 03 | 03 |
| 308 | 75 | - |
| 309 | 53 | ( |
| 310 | 01 | 1 |
| 311 | 00 | 0 |
| 312 | 05 | 5 |
| 313 | 02 | 2 |
| 314 | 93 | . |
| 315 | 01 | 1 |
| 316 | 02 | 2 |
| 317 | 03 | 3 |
| 318 | 75 | - |
| 319 | 01 | 1 |
| 320 | 02 | 2 |
| 321 | 03 | 3 |
| 322 | 01 | 1 |
| 323 | 93 | . |
| 324 | 02 | 2 |
| 325 | 04 | 4 |
| 326 | 65 | × |
| 327 | 43 | RCL |
| 328 | 09 | 09 |
| 329 | 85 | + |
| 330 | 04 | 4 |
| 331 | 08 | 8 |
| 332 | 07 | 7 |
| 333 | 93 | . |
| 334 | 04 | 4 |
| 335 | 02 | 2 |
| 336 | 03 | 3 |
| 337 | 03 | 3 |
| 338 | 65 | × |
| 339 | 43 | RCL |
| 340 | 09 | 09 |
| 341 | 33 | X² |
| 342 | 75 | - |
| 343 | 09 | 9 |
| 344 | 01 | 1 |
| 345 | 93 | . |
| 346 | 06 | 6 |
| 347 | 05 | 5 |
| 348 | 02 | 2 |
| 349 | 02 | 2 |
| 350 | 65 | × |
| 351 | 43 | RCL |
| 352 | 09 | 09 |
| 353 | 45 | Y× |
| 354 | 03 | 3 |
| 355 | 85 | + |
| 356 | 08 | 8 |
| 357 | 93 | . |
| 358 | 06 | 6 |
| 359 | 06 | 6 |
| 360 | 02 | 2 |
| 361 | 09 | 9 |
| 362 | 06 | 6 |
| 363 | 02 | 2 |
| 364 | 65 | × |
| 365 | 43 | RCL |
| 366 | 09 | 09 |
| 367 | 45 | Y× |
| 368 | 04 | 4 |
| 369 | 75 | - |
| 370 | 93 | . |
| 371 | 03 | 3 |
| 372 | 09 | 9 |
| 373 | 05 | 5 |
| 374 | 03 | 3 |
| 375 | 09 | 9 |
| 376 | 07 | 7 |

```
377  04  4
378  65  ×
379  43  RCL
380  09  09
381  45  Y^x
382  05  5
383  85  +
384  93  .
385  00  0
386  00  0
387  06  6
388  09  9
389  00  0
390  05  5
391  05  5
392  03  3
393  05  5
394  65  ×
395  43  RCL
396  09  09
397  45  Y^x
398  06  6
399  54  )
400  65  ×
401  43  RCL
402  03  03
403  33  X^2
404  85  +
405  53  (
406  01  1
407  06  6
408  08  8
409  00  0
410  93  .
411  01  1
412  04  4
413  02  2
414  75  -
415  01  1
416  09  9
417  05  5
418  00  0
419  93  .
420  01  1
421  03  3
422  09  9
423  65  ×
424  43  RCL
425  09  09
426  85  +
427  07  7
428  08  8
429  08  8
430  93  .
431  08  8
432  05  5
433  01  1
434  03  3
435  65  ×
436  43  RCL
437  09  09
438  33  X^2
439  75  -
440  01  1
441  05  5
442  02  2
443  93  .
444  05  5
445  07  7
446  03  3
447  03  3
448  65  ×
449  43  RCL
450  09  09
451  45  Y^x
452  03  3
453  85  +
454  01  1
455  05  5
456  93  .
457  00  0
458  03  3
459  08  8
460  01  1
461  09  9
462  65  ×
463  43  RCL
464  09  09
465  45  Y^x
466  04  4
467  75  -
468  93  .
469  07  7
470  02  2
471  07  7
472  04  4
473  01  1
474  03  3
475  09  9
476  65  ×
477  43  RCL
478  09  09
479  45  Y^x
480  05  5
481  85  +
482  93  .
483  00  0
484  01  1
485  03  3
486  07  7
487  00  0
488  07  7
489  65  ×
490  43  RCL
491  09  09
492  45  Y^x
493  06  6
494  54  )
495  65  ×
496  43  RCL
497  03  03
498  45  Y^x
499  03  3
500  75  -
501  53  (
502  08  8
503  06  6
504  04  4
505  93  .
506  06  6
507  08  8
508  07  7
509  05  5
510  75  -
511  01  1
512  00  0
513  00  0
514  00  0
515  93  .
516  04  4
517  04  4
518  03  3
519  65  ×
520  43  RCL
521  09  09
522  85  +
523  04  4
524  00  0
525  08  8
526  93  .
```

| | | |
|---|---|---|
| 527 | 07 | 7 |
| 528 | 04 | 4 |
| 529 | 05 | 5 |
| 530 | 01 | 1 |
| 531 | 65 | × |
| 532 | 43 | RCL |
| 533 | 09 | 09 |
| 534 | 33 | X² |
| 535 | 75 | - |
| 536 | 08 | 8 |
| 537 | 00 | 0 |
| 538 | 93 | . |
| 539 | 00 | 0 |
| 540 | 08 | 8 |
| 541 | 03 | 3 |
| 542 | 01 | 1 |
| 543 | 04 | 4 |
| 544 | 65 | × |
| 545 | 43 | RCL |
| 546 | 09 | 09 |
| 547 | 45 | Y<sup>X</sup> |
| 548 | 03 | 3 |
| 549 | 85 | + |
| 550 | 08 | 8 |
| 551 | 93 | . |
| 552 | 00 | 0 |
| 553 | 03 | 3 |
| 554 | 09 | 9 |
| 555 | 05 | 5 |
| 556 | 08 | 8 |
| 557 | 65 | × |
| 558 | 43 | RCL |
| 559 | 09 | 09 |
| 560 | 45 | Y<sup>X</sup> |
| 561 | 04 | 4 |
| 562 | 75 | - |
| 563 | 93 | . |
| 564 | 03 | 3 |
| 565 | 09 | 9 |
| 566 | 08 | 8 |
| 567 | 02 | 2 |
| 568 | 05 | 5 |
| 569 | 02 | 2 |
| 570 | 07 | 7 |
| 571 | 65 | × |
| 572 | 43 | RCL |
| 573 | 09 | 09 |
| 574 | 45 | Y<sup>X</sup> |
| 575 | 05 | 5 |
| 576 | 85 | + |
| 577 | 93 | . |
| 578 | 00 | 0 |
| 579 | 00 | 0 |
| 580 | 07 | 7 |
| 581 | 07 | 7 |
| 582 | 02 | 2 |
| 583 | 00 | 0 |
| 584 | 06 | 6 |
| 585 | 01 | 1 |
| 586 | 07 | 7 |
| 587 | 65 | × |
| 588 | 43 | RCL |
| 589 | 09 | 09 |
| 590 | 45 | Y<sup>X</sup> |
| 591 | 06 | 6 |
| 592 | 54 | ) |
| 593 | 65 | × |
| 594 | 43 | RCL |
| 595 | 03 | 03 |
| 596 | 45 | Y<sup>X</sup> |
| 597 | 04 | 4 |
| 598 | 95 | = |
| 599 | 42 | STO |
| 600 | 05 | 05 |
| 601 | 92 | RTN |
| 602 | 04 | 4 |
| 603 | 93 | . |
| 604 | 09 | 9 |
| 605 | 07 | 7 |
| 606 | 04 | 4 |
| 607 | 02 | 2 |
| 608 | 65 | × |
| 609 | 43 | RCL |
| 610 | 07 | 07 |
| 611 | 85 | + |
| 612 | 07 | 7 |
| 613 | 93 | . |
| 614 | 09 | 9 |
| 615 | 00 | 0 |
| 616 | 04 | 4 |
| 617 | 03 | 3 |
| 618 | 52 | EE |
| 619 | 94 | +/- |
| 620 | 06 | 6 |
| 621 | 65 | × |
| 622 | 43 | RCL |
| 623 | 07 | 07 |
| 624 | 33 | X² |
| 625 | 95 | = |
| 626 | 42 | STO |
| 627 | 07 | 07 |
| 628 | 22 | INV |
| 629 | 52 | EE |
| 630 | 65 | × |
| 631 | 01 | 1 |
| 632 | 00 | 0 |
| 633 | 00 | 0 |
| 634 | 95 | = |
| 635 | 59 | INT |
| 636 | 55 | ÷ |
| 637 | 01 | 1 |
| 638 | 00 | 0 |
| 639 | 00 | 0 |
| 640 | 95 | = |
| 641 | 91 | R/S |
| 642 | 53 | ( |
| 643 | 06 | 6 |
| 644 | 93 | . |
| 645 | 04 | 4 |
| 646 | 01 | 1 |
| 647 | 07 | 7 |
| 648 | 05 | 5 |
| 649 | 85 | + |
| 650 | 93 | . |
| 651 | 00 | 0 |
| 652 | 01 | 1 |
| 653 | 00 | 0 |
| 654 | 04 | 4 |
| 655 | 02 | 2 |
| 656 | 06 | 6 |
| 657 | 65 | × |
| 658 | 43 | RCL |
| 659 | 04 | 04 |
| 660 | 75 | - |
| 661 | 06 | 6 |
| 662 | 93 | . |
| 663 | 08 | 8 |
| 664 | 09 | 9 |
| 665 | 02 | 2 |
| 666 | 05 | 5 |
| 667 | 52 | EE |
| 668 | 94 | +/- |
| 669 | 06 | 6 |
| 670 | 65 | × |
| 671 | 43 | RCL |
| 672 | 04 | 04 |
| 673 | 33 | X² |
| 674 | 85 | + |
| 675 | 04 | 4 |
| 676 | 93 | . |

| | | |
|---|---|---|
| 677 | 09 | 9 |
| 678 | 01 | 1 |
| 679 | 02 | 2 |
| 680 | 07 | 7 |
| 681 | 52 | EE |
| 682 | 94 | +/- |
| 683 | 07 | 7 |
| 684 | 65 | × |
| 685 | 43 | RCL |
| 686 | 04 | 04 |
| 687 | 33 | X² |
| 688 | 65 | × |
| 689 | 43 | RCL |
| 690 | 04 | 04 |
| 691 | 54 | ) |
| 692 | 65 | × |
| 693 | 43 | RCL |
| 694 | 03 | 03 |
| 695 | 95 | = |
| 696 | 42 | STO |
| 697 | 08 | 08 |
| 698 | 93 | . |
| 699 | 01 | 1 |
| 700 | 65 | × |
| 701 | 43 | RCL |
| 702 | 07 | 07 |
| 703 | 65 | × |
| 704 | 43 | RCL |
| 705 | 08 | 08 |
| 706 | 95 | = |
| 707 | 65 | × |
| 708 | 01 | 1 |
| 709 | 00 | 0 |
| 710 | 00 | 0 |
| 711 | 00 | 0 |
| 712 | 95 | = |
| 713 | 59 | INT |
| 714 | 22 | INV |
| 715 | 52 | EE |
| 716 | 91 | R/S |

USER INFORMATION FOR PROGRAM 2

Program: Takeoff Ground Roll Distance

Number of Steps: 1385

Computation Time: 48-50 seconds

| STEP | ENTER | PRESS KEY | DISPLAY |
|---|---|---|---|
| 1 | gross weight (lbs.) | A | gross weight |
| 2 | pressure altitude (ft.) | B | Pressure altitude |
| 3 | temperature (°C) | E | temperature |
| 4 | headwind (kts.) | 2nd,D | headwind |
| 5 | relative humidity (%) | 2nd,E | unusable number |
| 6 | --- | R/S | unusable number |
| 7 | read in cards 3 & 4 | R/S | --- |
| 8 | --- | 2nd,A | unusable number |
| 9 | flap position (degrees) | 2nd,B | flap position |
| 0 | center of gravity (%) | 2nd,C | center of gravity |
| 1 | runway slope (%) | - | takeoff ground roll distance |

```
000  76 LBL      050  05  5       100  07  7
001  12  B       051  52 EE       101  93  .
002  42 STO      052  94 +/-      102  08  8
003  00  00      053  07  7       103  09  9
004  91 R/S      054  65  ×       104  03  3
005  76 LBL      055  43 RCL      105  01  1
006  15  E       056  00  00      106  52 EE
007  42 STO      057  33 X²       107  94 +/-
008  01  01      058  85  +       108  06  6
009  91 R/S      059  03  3       109  65  ×
010  76 LBL      060  93  .       110  43 RCL
011  11  A       061  06  6       111  00  00
012  42 STO      062  08  8       112  75  -
013  02  02      063  06  6       113  03  3
014  91 R/S      064  01  1       114  93  .
015  76 LBL      065  52 EE       115  07  7
016  19 D'       066  94 +/-      116  05  5
017  42 STO      067  01  1       117  04  4
018  04  04      068  01  1       118  05  5
019  91 R/S      069  65  ×       119  52 EE
020  76 LBL      070  43 RCL      120  94 +/-
021  10 E'       071  00  00      121  09  9
022  42 STO      072  45 YX       122  65  ×
023  03  03      073  03  3       123  43 RCL
024  53  (       074  75  -       124  00  00
025  01  1       075  02  2       125  33 X²
026  03  3       076  93  .       126  85  +
027  93  .       077  04  4       127  09  9
028  00  0       078  01  1       128  93  .
029  08  8       079  05  5       129  07  7
030  06  6       080  06  6       130  00  0
031  75  -       081  52 EE       131  08  8
032  93  .       082  94 +/-      132  08  8
033  00  0       083  01  1       133  52 EE
034  00  0       084  05  5       134  94 +/-
035  00  0       085  65  ×       135  01  1
036  01  1       086  43 RCL      136  03  3
037  07  7       087  00  00      137  65  ×
038  01  1       088  45 YX       138  43 RCL
039  01  1       089  04  4       139  00  00
040  03  3       090  54  )       140  45 YX
041  65  ×       091  75  -       141  03  3
042  43 RCL      092  53  (       142  75  -
043  00  00      093  93  .       143  06  6
044  75  -       094  00  0       144  93  .
045  02  2       095  04  4       145  09  9
046  93  .       096  05  5       146  09  9
047  00  0       097  06  6       147  07  7
048  06  6       098  03  3       148  52 EE
049  05  5       099  85  +       149  94 +/-
```

```
150  01   1
151  07   7
152  65   ×
153  43  RCL
154  00   00
155  45  Yˣ
156  04   4
157  54   )
158  65   ×
159  53   (
160  43  RCL
161  01   01
162  54   )
163  75   -
164  53   (
165  93   .
166  00   0
167  00   0
168  01   1
169  03   3
170  01   1
171  07   7
172  85   +
173  08   8
174  93   .
175  02   2
176  05   5
177  05   5
178  08   8
179  52  EE
180  94  +/-
181  07   7
182  65   ×
183  43  RCL
184  00   00
185  75   -
186  04   4
187  93   .
188  00   0
189  07   7
190  03   3
191  09   9
192  02   2
193  52  EE
194  94  +/-
195  01   1
196  00   0
197  65   ×
198  43  RCL
199  00   00
200  33  X²
201  85   +
202  08   8
203  93   .
204  05   5
205  04   4
206  08   8
207  08   8
208  52  EE
209  94  +/-
210  01   1
211  04   4
212  65   ×
213  43  RCL
214  00   00
215  45  Yˣ
216  03   3
217  75   -
218  05   5
219  93   .
220  04   4
221  09   9
222  06   6
223  04   4
224  52  EE
225  94  +/-
226  01   1
227  08   8
228  65   ×
229  43  RCL
230  00   00
231  45  Yˣ
232  04   4
233  54   )
234  65   ×
235  53   (
236  43  RCL
237  01   01
238  33  X²
239  54   )
240  75   -
241  53   (
242  01   1
243  93   .
244  09   9
245  00   0
246  09   9
247  07   7
248  52  EE
249  94  +/-
250  05   5
251  75   -
252  01   1
253  93   .
254  03   3
255  06   6
256  07   7
257  01   1
258  52  EE
259  94  +/-
260  08   8
261  65   ×
262  43  RCL
263  00   00
264  85   +
265  09   9
266  93   .
267  04   4
268  06   6
269  09   9
270  04   4
271  52  EE
272  94  +/-
273  01   1
274  02   2
275  65   ×
276  43  RCL
277  00   00
278  33  X²
279  75   -
280  02   2
281  93   .
282  00   0
283  04   4
284  03   3
285  04   4
286  52  EE
287  94  +/-
288  01   1
289  05   5
290  65   ×
291  43  RCL
292  00   00
293  45  Yˣ
294  03   3
295  85   +
296  01   1
297  93   .
298  04   4
299  06   6
```

```
300  01  1
301  07  7
302  52  EE
303  94  +/-
304  01  1
305  09  9
306  65  ×
307  43  RCL
308  00  00
309  45  Yˣ
310  04  4
311  54  )
312  65  ×
313  53  (
314  43  RCL
315  01  01
316  45  Yˣ
317  03  3
318  54  )
319  95  =
320  65  ×
321  93  .
322  05  5
323  06  6
324  06  6
325  85  +
326  01  1
327  93  .
328  09  9
329  09  9
330  07  7
331  03  3
332  95  =
333  65  ×
334  53  (
335  05  5
336  93  .
337  08  8
338  06  6
339  02  2
340  01  1
341  52  EE
342  04  4
343  75  -
344  01  1
345  00  0
346  93  .
347  01  1
348  04  4
349  06  6
350  65  ×
351  43  RCL
352  02  02
353  85  +
354  06  6
355  93  .
356  08  8
357  08  8
358  00  0
359  07  7
360  52  EE
361  94  +/-
362  04  4
363  65  ×
364  43  RCL
365  02  02
366  33  X²
367  75  -
368  02  2
369  93  .
370  02  2
371  09  9
372  02  2
373  52  EE
374  94  +/-
375  08  8
376  65  ×
377  43  RCL
378  02  02
379  45  Yˣ
380  03  3
381  85  +
382  03  3
383  93  .
384  07  7
385  03  3
386  08  8
387  07  7
388  52  EE
389  94  +/-
390  01  1
391  03  3
392  65  ×
393  43  RCL
394  02  02
395  45  Yˣ
396  04  4
397  75  -
398  02  2
399  93  .
400  03  3
401  09  9
402  06  6
403  04  4
404  52  EE
405  94  +/-
406  01  1
407  08  8
408  65  ×
409  43  RCL
410  02  02
411  45  Yˣ
412  05  5
413  54  )
414  75  -
415  53  (
416  04  4
417  93  .
418  08  8
419  08  8
420  09  9
421  06  6
422  52  EE
423  05  5
424  75  -
425  08  8
426  04  4
427  93  .
428  09  9
429  07  7
430  04  4
431  65  ×
432  43  RCL
433  02  02
434  85  +
435  05  5
436  93  .
437  07  7
438  08  8
439  05  5
440  06  6
441  52  EE
442  94  +/-
443  03  3
444  65  ×
445  43  RCL
446  02  02
447  33  X²
448  75  -
449  01  1
```

```
450  93  .
451  09  9
452  03  3
453  07  7
454  03  3
455  52  EE
456  94  +/-
457  07  7
458  65  ×
459  43  RCL
460  02  02
461  45  Y×
462  03  3
463  85  +
464  03  3
465  93  .
466  01  1
467  07  7
468  04  4
469  04  4
470  52  EE
471  94  +/-
472  01  1
473  02  2
474  65  ×
475  43  RCL
476  02  02
477  45  Y×
478  04  4
479  75  -
480  02  2
481  93  .
482  00  0
483  04  4
484  04  4
485  06  6
486  52  EE
487  94  +/-
488  01  1
489  07  7
490  65  ×
491  43  RCL
492  02  02
493  45  Y×
494  05  5
495  54  )
496  95  =
497  42  STO
498  09  09
499  43  RCL
500  03  03
501  32  X:T
502  04  4
503  00  0
504  22  INV
505  77  GE
506  05  05
507  13  13
508  25  CLR
509  04  4
510  00  0
511  42  STO
512  03  03
513  43  RCL
514  09  09
515  65  ×
516  53  (
517  01  1
518  85  +
519  53  (
520  43  RCL
521  03  03
522  75  -
523  04  4
524  00  0
525  54  )
526  55  ÷
527  01  1
528  00  0
529  00  0
530  00  0
531  54  )
532  95  =
533  42  STO
534  09  09
535  06  6
536  07  7
537  93  .
538  01  1
539  02  2
540  04  4
541  85  +
542  93  .
543  08  8
544  09  9
545  05  5
546  00  0
547  09  9
548  65  ×
549  43  RCL
550  09  09
551  85  +
552  02  2
553  93  .
554  03  3
555  03  3
556  00  0
557  06  6
558  52  EE
559  94  +/-
560  05  5
561  65  ×
562  43  RCL
563  09  09
564  33  X²
565  75  -
566  01  1
567  93  .
568  06  6
569  02  2
570  05  5
571  04  4
572  52  EE
573  94  +/-
574  09  9
575  65  ×
576  43  RCL
577  09  09
578  45  Y×
579  03  3
580  85  +
581  03  3
582  93  .
583  03  3
584  07  7
585  02  2
586  08  8
587  52  EE
588  94  +/-
589  01  1
590  04  4
591  65  ×
592  43  RCL
593  09  09
594  45  Y×
595  04  4
596  75  -
597  53  (
598  09  9
599  93  .
```

```
600  00   0
601  09   9
602  09   9
603  05   5
604  85   +
605  93   .
606  00   0
607  01   1
608  00   0
609  08   8
610  05   5
611  06   6
612  65   X
613  43  RCL
614  09   09
615  75   -
616  02   2
617  93   .
618  01   1
619  07   7
620  05   5
621  04   4
622  52  EE
623  94  +/-
624  07   7
625  65   X
626  43  RCL
627  09   09
628  33  X²
629  85   +
630  02   2
631  93   .
632  05   5
633  03   3
634  02   2
635  07   7
636  52  EE
637  94  +/-
638  01   1
639  01   1
640  65   X
641  43  RCL
642  09   09
643  45  YX
644  03   3
645  75   -
646  01   1
647  93   .
648  01   1
649  09   9
650  07   7
651  52  EE
652  94  +/-
653  01   1
654  05   5
655  65   X
656  43  RCL
657  09   09
658  45  YX
659  04   4
660  54   )
661  65   X
662  43  RCL
663  04   04
664  85   +
665  53   (
666  93   .
667  01   1
668  04   4
669  07   7
670  08   8
671  02   2
672  75   -
673  02   2
674  93   .
675  01   1
676  06   6
677  06   6
678  06   6
679  52  EE
680  94  +/-
681  06   6
682  65   X
683  43  RCL
684  09   09
685  85   +
686  03   3
687  93   .
688  04   4
689  02   2
690  07   7
691  04   4
692  52  EE
693  94  +/-
694  09   9
695  65   X
696  43  RCL
697  09   09
698  33  X²
699  75   -
700  02   2
701  93   .
702  07   7
703  08   8
704  01   1
705  07   7
706  52  EE
707  94  +/-
708  01   1
709  03   3
710  65   X
711  43  RCL
712  09   09
713  45  YX
714  03   3
715  85   +
716  09   9
717  93   .
718  03   3
719  00   0
720  07   7
721  07   7
722  52  EE
723  94  +/-
724  01   1
725  08   8
726  65   X
727  43  RCL
728  09   09
729  45  YX
730  04   4
731  54   )
732  65   X
733  43  RCL
734  04   04
735  33  X²
736  95   =
737  91  R/S
738  32  X:T
739  91  R/S
740  00   0
741  00   0
000  32  X:T
001  42  STO
002  09   09
003  91  R/S
004  76  LBL
005  16  A'
006  42  STO
007  07   07
```

```
008  91 R/S
009  76 LBL
010  17 B'
011  42 STO
012  06  06
013  91 R/S
014  76 LBL
015  18 C'
016  42 STO
017  05  05
018  53  (
019  04  4
020  05  5
021  93  .
022  07  7
023  00  0
024  04  4
025  85  +
026  93  .
027  09  9
028  03  3
029  04  4
030  02  2
031  09  9
032  65  ×
033  43 RCL
034  09  09
035  85  +
036  02  2
037  93  .
038  02  2
039  02  2
040  06  6
041  05  5
042  52 EE
043  94 +/-
044  05  5
045  65  ×
046  43 RCL
047  09  09
048  33 X²
049  75  -
050  02  2
051  93  .
052  03  3
053  03  3
054  08  8
055  52 EE
056  94 +/-
057  09  9
058  65  ×
059  43 RCL
060  09  09
061  45 Y^X
062  03  3
063  85  +
064  07  7
065  93  .
066  09  9
067  04  4
068  01  1
069  52 EE
070  94 +/-
071  01  1
072  04  4
073  65  ×
074  43 RCL
075  09  09
076  45 Y^X
077  04  4
078  54  )
079  85  +
080  53  (
081  07  7
082  93  .
083  09  9
084  04  4
085  07  7
086  02  2
087  85  +
088  01  1
089  93  .
090  04  4
091  09  9
092  01  1
093  04  4
094  52 EE
095  94 +/-
096  02  2
097  65  ×
098  43 RCL
099  09  09
100  85  +
101  09  9
102  93  .
103  00  0
104  07  7
105  00  0
106  07  7
107  52 EE
108  94 +/-
109  06  6
110  65  ×
111  43 RCL
112  09  09
113  33 X²
114  75  -
115  07  7
116  93  .
117  01  1
118  02  2
119  03  3
120  05  5
121  52 EE
122  94 +/-
123  01  1
124  00  0
125  65  ×
126  43 RCL
127  09  09
128  45 Y^X
129  03  3
130  85  +
131  03  3
132  93  .
133  00  0
134  06  6
135  08  8
136  04  4
137  52 EE
138  94 +/-
139  01  1
140  04  4
141  65  ×
142  43 RCL
143  09  09
144  45 Y^X
145  04  4
146  54  )
147  65  ×
148  43 RCL
149  05  05
150  85  +
151  53  (
152  05  5
153  93  .
154  03  3
155  06  6
156  01  1
157  06  6
```

```
158  75   -
159  08   8
160  93   .
161  05   5
162  01   1
163  03   3
164  06   6
165  52  EE
166  94  +/-
167  03   3
168  65   X
169  43  RCL
170  09   09
171  85   +
172  03   3
173  93   .
174  05   5
175  09   9
176  01   1
177  04   4
178  52  EE
179  94  +/-
180  06   6
181  65   X
182  43  RCL
183  09   09
184  33  X²
185  75   -
186  04   4
187  93   .
188  05   5
189  09   9
190  03   3
191  02   2
192  52  EE
193  94  +/-
194  01   1
195  00   0
196  65   X
197  43  RCL
198  09   09
199  45  YX
200  03   3
201  85   +
202  01   1
203  93   .
204  09   9
205  08   8
206  08   8
207  09   9
208  52  EE
209  94  +/-
210  01   1
211  04   4
212  65   X
213  43  RCL
214  09   09
215  45  YX
216  04   4
217  54   )
218  65   X
219  53   (
220  43  RCL
221  05   05
222  33  X²
223  54   )
224  95   =
225  42  STO
226  09   09
227  53   (
228  02   2
229  93   .
230  06   6
231  00   0
232  04   4
233  02   2
234  52  EE
235  03   3
236  75   -
237  02   2
238  93   .
239  01   1
240  06   6
241  09   9
242  04   4
243  65   X
244  43  RCL
245  09   09
246  85   +
247  01   1
248  93   .
249  00   0
250  09   9
251  01   1
252  05   5
253  52  EE
254  94  +/-
255  03   3
256  65   X
257  43  RCL
258  09   09
259  33  X²
260  75   -
261  01   1
262  93   .
263  01   1
264  01   1
265  01   1
266  09   9
267  52  EE
268  94  +/-
269  07   7
270  65   X
271  43  RCL
272  09   09
273  45  YX
274  03   3
275  85   +
276  03   3
277  93   .
278  06   6
279  06   6
280  02   2
281  52  EE
282  94  +/-
283  01   1
284  02   2
285  65   X
286  43  RCL
287  09   09
288  45  YX
289  04   4
290  54   )
291  75   -
292  53   (
293  01   1
294  93   .
295  07   7
296  05   5
297  07   7
298  03   3
299  52  EE
300  02   2
301  75   -
302  93   .
303  02   2
304  02   2
305  06   6
306  00   0
307  01   1
```

| | | |
|---|---|---|
| 308 | 65 | × |
| 309 | 43 | RCL |
| 310 | 09 | 09 |
| 311 | 85 | + |
| 312 | 07 | 7 |
| 313 | 93 | . |
| 314 | 05 | 5 |
| 315 | 02 | 2 |
| 316 | 02 | 2 |
| 317 | 05 | 5 |
| 318 | 52 | EE |
| 319 | 94 | +/- |
| 320 | 05 | 5 |
| 321 | 65 | × |
| 322 | 43 | RCL |
| 323 | 09 | 09 |
| 324 | 33 | X² |
| 325 | 75 | - |
| 326 | 07 | 7 |
| 327 | 93 | . |
| 328 | 07 | 7 |
| 329 | 00 | 0 |
| 330 | 01 | 1 |
| 331 | 08 | 8 |
| 332 | 52 | EE |
| 333 | 94 | +/- |
| 334 | 09 | 9 |
| 335 | 65 | × |
| 336 | 43 | RCL |
| 337 | 09 | 09 |
| 338 | 45 | Y^X |
| 339 | 03 | 3 |
| 340 | 85 | + |
| 341 | 02 | 2 |
| 342 | 93 | . |
| 343 | 05 | 5 |
| 344 | 04 | 4 |
| 345 | 03 | 3 |
| 346 | 07 | 7 |
| 347 | 52 | EE |
| 348 | 94 | +/- |
| 349 | 01 | 1 |
| 350 | 03 | 3 |
| 351 | 65 | × |
| 352 | 43 | RCL |
| 353 | 09 | 09 |
| 354 | 45 | Y^X |
| 355 | 04 | 4 |
| 356 | 54 | ) |
| 357 | 65 | × |
| 358 | 43 | RCL |
| 359 | 06 | 06 |
| 360 | 85 | + |
| 361 | 53 | ( |
| 362 | 02 | 2 |
| 363 | 93 | . |
| 364 | 08 | 8 |
| 365 | 05 | 5 |
| 366 | 04 | 4 |
| 367 | 09 | 9 |
| 368 | 75 | - |
| 369 | 04 | 4 |
| 370 | 93 | . |
| 371 | 00 | 0 |
| 372 | 01 | 1 |
| 373 | 00 | 0 |
| 374 | 02 | 2 |
| 375 | 52 | EE |
| 376 | 94 | +/- |
| 377 | 03 | 3 |
| 378 | 65 | × |
| 379 | 43 | RCL |
| 380 | 09 | 09 |
| 381 | 85 | + |
| 382 | 01 | 1 |
| 383 | 93 | . |
| 384 | 02 | 2 |
| 385 | 08 | 8 |
| 386 | 03 | 3 |
| 387 | 02 | 2 |
| 388 | 52 | EE |
| 389 | 94 | +/- |
| 390 | 06 | 6 |
| 391 | 65 | × |
| 392 | 43 | RCL |
| 393 | 09 | 09 |
| 394 | 33 | X² |
| 395 | 75 | - |
| 396 | 01 | 1 |
| 397 | 93 | . |
| 398 | 03 | 3 |
| 399 | 02 | 2 |
| 400 | 03 | 3 |
| 401 | 04 | 4 |
| 402 | 52 | EE |
| 403 | 94 | +/- |
| 404 | 01 | 1 |
| 405 | 00 | 0 |
| 406 | 65 | × |
| 407 | 43 | RCL |
| 408 | 09 | 09 |
| 409 | 45 | Y^X |
| 410 | 03 | 3 |
| 411 | 85 | + |
| 412 | 04 | 4 |
| 413 | 93 | . |
| 414 | 03 | 3 |
| 415 | 09 | 9 |
| 416 | 00 | 0 |
| 417 | 08 | 8 |
| 418 | 52 | EE |
| 419 | 94 | +/- |
| 420 | 01 | 1 |
| 421 | 05 | 5 |
| 422 | 65 | × |
| 423 | 43 | RCL |
| 424 | 09 | 09 |
| 425 | 45 | Y^X |
| 426 | 04 | 4 |
| 427 | 54 | ) |
| 428 | 65 | × |
| 429 | 53 | ( |
| 430 | 43 | RCL |
| 431 | 06 | 06 |
| 432 | 33 | X² |
| 433 | 54 | ) |
| 434 | 95 | = |
| 435 | 42 | STO |
| 436 | 09 | 09 |
| 437 | 25 | CLR |
| 438 | 75 | - |
| 439 | 53 | ( |
| 440 | 04 | 4 |
| 441 | 00 | 0 |
| 442 | 00 | 0 |
| 443 | 93 | . |
| 444 | 07 | 7 |
| 445 | 09 | 9 |
| 446 | 75 | - |
| 447 | 01 | 1 |
| 448 | 93 | . |
| 449 | 05 | 5 |
| 450 | 08 | 8 |
| 451 | 00 | 0 |
| 452 | 01 | 1 |
| 453 | 65 | × |
| 454 | 43 | RCL |
| 455 | 09 | 09 |
| 456 | 85 | + |
| 457 | 02 | 2 |

| | | |
|---|---|---|
| 458 | 93 | . |
| 459 | 00 | 0 |
| 460 | 02 | 2 |
| 461 | 05 | 5 |
| 462 | 04 | 4 |
| 463 | 52 | EE |
| 464 | 94 | +/- |
| 465 | 04 | 4 |
| 466 | 65 | × |
| 467 | 43 | RCL |
| 468 | 09 | 09 |
| 469 | 33 | $X^2$ |
| 470 | 75 | - |
| 471 | 02 | 2 |
| 472 | 93 | . |
| 473 | 04 | 4 |
| 474 | 01 | 1 |
| 475 | 01 | 1 |
| 476 | 01 | 1 |
| 477 | 52 | EE |
| 478 | 94 | +/- |
| 479 | 08 | 8 |
| 480 | 65 | × |
| 481 | 43 | RCL |
| 482 | 09 | 09 |
| 483 | 45 | $Y^X$ |
| 484 | 03 | 3 |
| 485 | 85 | + |
| 486 | 08 | 8 |
| 487 | 93 | . |
| 488 | 06 | 6 |
| 489 | 07 | 7 |
| 490 | 03 | 3 |
| 491 | 07 | 7 |
| 492 | 52 | EE |
| 493 | 94 | +/- |
| 494 | 01 | 1 |
| 495 | 03 | 3 |
| 496 | 65 | × |
| 497 | 43 | RCL |
| 498 | 09 | 09 |
| 499 | 45 | $Y^X$ |
| 500 | 04 | 4 |
| 501 | 54 | ) |
| 502 | 85 | + |
| 503 | 53 | ( |
| 504 | 01 | 1 |
| 505 | 06 | 6 |
| 506 | 93 | . |
| 507 | 01 | 1 |
| 508 | 09 | 9 |
| 509 | 06 | 6 |
| 510 | 75 | - |
| 511 | 93 | . |
| 512 | 00 | 0 |
| 513 | 02 | 2 |
| 514 | 04 | 4 |
| 515 | 03 | 3 |
| 516 | 03 | 3 |
| 517 | 03 | 3 |
| 518 | 65 | × |
| 519 | 43 | RCL |
| 520 | 09 | 09 |
| 521 | 85 | + |
| 522 | 09 | 9 |
| 523 | 93 | . |
| 524 | 03 | 3 |
| 525 | 04 | 4 |
| 526 | 08 | 8 |
| 527 | 04 | 4 |
| 528 | 52 | EE |
| 529 | 94 | +/- |
| 530 | 06 | 6 |
| 531 | 65 | × |
| 532 | 43 | RCL |
| 533 | 09 | 09 |
| 534 | 33 | $X^2$ |
| 535 | 75 | - |
| 536 | 01 | 1 |
| 537 | 93 | . |
| 538 | 02 | 2 |
| 539 | 05 | 5 |
| 540 | 09 | 9 |
| 541 | 04 | 4 |
| 542 | 52 | EE |
| 543 | 94 | +/- |
| 544 | 09 | 9 |
| 545 | 65 | × |
| 546 | 43 | RCL |
| 547 | 09 | 09 |
| 548 | 45 | $Y^X$ |
| 549 | 03 | 3 |
| 550 | 85 | + |
| 551 | 04 | 4 |
| 552 | 93 | . |
| 553 | 07 | 7 |
| 554 | 05 | 5 |
| 555 | 02 | 2 |
| 556 | 02 | 2 |
| 557 | 52 | EE |
| 558 | 94 | +/- |
| 559 | 01 | 1 |
| 560 | 04 | 4 |
| 561 | 65 | × |
| 562 | 43 | RCL |
| 563 | 09 | 09 |
| 564 | 45 | $Y^X$ |
| 565 | 04 | 4 |
| 566 | 54 | ) |
| 567 | 65 | × |
| 568 | 43 | RCL |
| 569 | 07 | 07 |
| 570 | 75 | - |
| 571 | 53 | ( |
| 572 | 93 | . |
| 573 | 01 | 1 |
| 574 | 04 | 4 |
| 575 | 07 | 7 |
| 576 | 05 | 5 |
| 577 | 08 | 8 |
| 578 | 75 | - |
| 579 | 02 | 2 |
| 580 | 93 | . |
| 581 | 03 | 3 |
| 582 | 05 | 5 |
| 583 | 09 | 9 |
| 584 | 52 | EE |
| 585 | 94 | +/- |
| 586 | 04 | 4 |
| 587 | 65 | × |
| 588 | 43 | RCL |
| 589 | 09 | 09 |
| 590 | 85 | + |
| 591 | 01 | 1 |
| 592 | 93 | . |
| 593 | 00 | 0 |
| 594 | 03 | 3 |
| 595 | 07 | 7 |
| 596 | 52 | EE |
| 597 | 94 | +/- |
| 598 | 07 | 7 |
| 599 | 65 | × |
| 600 | 43 | RCL |
| 601 | 09 | 09 |
| 602 | 33 | $X^2$ |
| 603 | 75 | - |
| 604 | 01 | 1 |
| 605 | 93 | . |
| 606 | 06 | 6 |
| 607 | 00 | 0 |

| | | |
|---|---|---|
| 608 | 01 | 1 |
| 609 | 06 | 6 |
| 610 | 52 | EE |
| 611 | 94 | +/- |
| 612 | 01 | 1 |
| 613 | 01 | 1 |
| 614 | 65 | × |
| 615 | 43 | RCL |
| 616 | 09 | 09 |
| 617 | 45 | $Y^X$ |
| 618 | 03 | 3 |
| 619 | 85 | + |
| 620 | 06 | 6 |
| 621 | 93 | . |
| 622 | 03 | 3 |
| 623 | 01 | 1 |
| 624 | 09 | 9 |
| 625 | 05 | 5 |
| 626 | 52 | EE |
| 627 | 94 | +/- |
| 628 | 01 | 1 |
| 629 | 06 | 6 |
| 630 | 65 | × |
| 631 | 43 | RCL |
| 632 | 09 | 09 |
| 633 | 45 | $Y^X$ |
| 634 | 04 | 4 |
| 635 | 54 | ) |
| 636 | 65 | × |
| 637 | 53 | ( |
| 638 | 43 | RCL |
| 639 | 07 | 07 |
| 640 | 33 | $X^2$ |
| 641 | 54 | ) |
| 642 | 95 | = |
| 643 | 59 | INT |
| 644 | 22 | INV |
| 645 | 52 | EE |
| 646 | 91 | R/S |
| 647 | 00 | 0 |
| 648 | 00 | 0 |
| 649 | 00 | 0 |

USER INFORMATION FOR PROGRAM 3

Program: Maximum Range Time and Speed at Constant Altitude

Number of Steps: 547

Computation Time: 20 seconds

| STEP | ENTER | PRESS KEY | DISPLAY |
|---|---|---|---|
| 1 | gross weight (lbs.) | A | gross weight/1000 |
| 2 | altitude (ft.) | B | altitude/1000 |
| 3 | drag count | C | drag count |
| 4 | temperature (°C) | E | temperature |
| 5 | distance (nautical miles) | 2nd,B | distance |
| 6 | headwind (kts.) | 2nd,C | mach number |
| 7 | --- | R/S | ground speed (kts.) |
| 8 | --- | R/S | time required (minutes) |

```
000  76  LBL
001  11   A
002  55   ÷
003  01   1
004  00   0
005  00   0
006  00   0
007  95   =
008  42  STO
009  00   00
010  91  R/S
011  76  LBL
012  12   B
013  55   ÷
014  01   1
015  00   0
016  00   0
017  00   0
018  95   =
019  42  STO
020  01   01
021  91  R/S
022  76  LBL
023  13   C
024  42  STO
025  02   02
026  91  R/S
027  76  LBL
028  15   E
029  42  STO
030  03   03
031  91  R/S
032  76  LBL
033  17  B'
034  42  STO
035  05   05
036  91  R/S
037  76  LBL
038  19  D'
039  42  STO
040  04   04
041  25  CLR
042  75   -
043  01   1
044  85   +
045  05   5
046  93   .
047  00   0
048  07   7
049  09   9
050  04   4
051  52  EE
052  94  +/-
053  03   3
054  65   x
055  43  RCL
056  01   01
057  75   -
058  01   1
059  93   .
060  03   3
061  09   9
062  06   6
063  08   8
064  52  EE
065  94  +/-
066  03   3
067  65   x
068  43  RCL
069  01   01
070  33  X^2
071  85   +
072  08   8
073  93   .
074  02   2
075  05   5
076  04   4
077  52  EE
078  94  +/-
079  05   5
080  65   x
081  43  RCL
082  01   01
083  45  Y^X
084  03   3
085  75   -
086  01   1
087  93   .
088  02   2
089  06   6
090  09   9
091  08   8
092  52  EE
093  94  +/-
094  06   6
095  65   x
096  43  RCL
097  01   01
098  45  Y^X
099  04   4
100  85   +
101  53   (
102  93   .
103  00   0
104  05   5
105  85   +
106  93   .
107  00   0
108  00   0
109  01   1
110  05   5
111  01   1
112  05   5
113  09   9
114  65   x
115  43  RCL
116  01   01
117  85   +
118  01   1
119  93   .
120  01   1
121  02   2
122  03   3
123  52  EE
124  94  +/-
125  04   4
126  65   x
127  43  RCL
128  01   01
129  33  X^2
130  75   -
131  03   3
132  93   .
133  04   4
134  09   9
135  02   2
136  01   1
137  52  EE
138  94  +/-
139  06   6
140  65   x
141  43  RCL
142  01   01
143  45  Y^X
144  03   3
145  85   +
146  07   7
147  93   .
148  09   9
149  03   3
```

```
150  06  6
151  05  5
152  52  EE
153  94  +/-
154  08  8
155  65  ×
156  43  RCL
157  01  01
158  45  Yˣ
159  04  4
160  54  )
161  65  ×
162  43  RCL
163  00  00
164  95  =
165  42  STO
166  06  06
167  25  CLR
168  93  .
169  04  4
170  07  7
171  08  8
172  00  0
173  03  3
174  75  -
175  93  .
176  00  0
177  00  0
178  01  1
179  03  3
180  04  4
181  01  1
182  07  7
183  65  ×
184  43  RCL
185  02  02
186  85  +
187  06  6
188  93  .
189  02  2
190  02  2
191  08  8
192  07  7
193  52  EE
194  94  +/-
195  06  6
196  65  ×
197  43  RCL
198  02  02
199  33  X²
200  75  -
201  01  1
202  93  .
203  06  6
204  02  2
205  06  6
206  01  1
207  52  EE
208  94  +/-
209  08  8
210  65  ×
211  43  RCL
212  02  02
213  45  Yˣ
214  03  3
215  85  +
216  01  1
217  93  .
218  06  6
219  04  4
220  03  3
221  08  8
222  52  EE
223  94  +/-
224  01  1
225  01  1
226  65  ×
227  43  RCL
228  02  02
229  45  Yˣ
230  04  4
231  85  +
232  53  (
233  93  .
234  00  0
235  08  8
236  02  2
237  01  1
238  07  7
239  85  +
240  04  4
241  93  .
242  01  1
243  02  2
244  00  0
245  09  9
246  52  EE
247  94  +/-
248  04  4
249  65  ×
250  43  RCL
251  02  02
252  75  -
253  04  4
254  93  .
255  05  5
256  05  5
257  07  7
258  07  7
259  52  EE
260  94  +/-
261  06  6
262  65  ×
263  43  RCL
264  02  02
265  33  X²
266  85  +
267  01  1
268  93  .
269  06  6
270  07  7
271  07  7
272  07  7
273  52  EE
274  94  +/-
275  08  8
276  65  ×
277  43  RCL
278  02  02
279  45  Yˣ
280  03  3
281  75  -
282  02  2
283  93  .
284  00  0
285  00  0
286  01  1
287  52  EE
288  94  +/-
289  01  1
290  01  1
291  65  ×
292  43  RCL
293  02  02
294  45  Yˣ
295  04  4
296  54  )
297  65  ×
298  43  RCL
299  06  06
```

| Step | Code | Key |
|---|---|---|
| 300 | 85 | + |
| 301 | 53 | ( |
| 302 | 93 | . |
| 303 | 00 | 0 |
| 304 | 00 | 0 |
| 305 | 00 | 0 |
| 306 | 04 | 4 |
| 307 | 02 | 2 |
| 308 | 01 | 1 |
| 309 | 04 | 4 |
| 310 | 03 | 3 |
| 311 | 75 | - |
| 312 | 09 | 9 |
| 313 | 93 | . |
| 314 | 04 | 4 |
| 315 | 03 | 3 |
| 316 | 09 | 9 |
| 317 | 07 | 7 |
| 318 | 52 | EE |
| 319 | 94 | +/- |
| 320 | 05 | 5 |
| 321 | 65 | × |
| 322 | 43 | RCL |
| 323 | 02 | 02 |
| 324 | 85 | + |
| 325 | 01 | 1 |
| 326 | 93 | . |
| 327 | 02 | 2 |
| 328 | 06 | 6 |
| 329 | 04 | 4 |
| 330 | 06 | 6 |
| 331 | 52 | EE |
| 332 | 94 | +/- |
| 333 | 06 | 6 |
| 334 | 65 | × |
| 335 | 43 | RCL |
| 336 | 02 | 02 |
| 337 | 33 | $X^2$ |
| 338 | 75 | - |
| 339 | 04 | 4 |
| 340 | 93 | . |
| 341 | 08 | 8 |
| 342 | 05 | 5 |
| 343 | 03 | 3 |
| 344 | 07 | 7 |
| 345 | 52 | EE |
| 346 | 94 | +/- |
| 347 | 09 | 9 |
| 348 | 65 | × |
| 349 | 43 | RCL |
| 350 | 02 | 02 |
| 351 | 45 | $Y^X$ |
| 352 | 03 | 3 |
| 353 | 85 | + |
| 354 | 05 | 5 |
| 355 | 93 | . |
| 356 | 07 | 7 |
| 357 | 02 | 2 |
| 358 | 02 | 2 |
| 359 | 02 | 2 |
| 360 | 52 | EE |
| 361 | 94 | +/- |
| 362 | 01 | 1 |
| 363 | 02 | 2 |
| 364 | 65 | × |
| 365 | 43 | RCL |
| 366 | 02 | 02 |
| 367 | 45 | $Y^X$ |
| 368 | 04 | 4 |
| 369 | 54 | ) |
| 370 | 65 | × |
| 371 | 53 | ( |
| 372 | 43 | RCL |
| 373 | 06 | 06 |
| 374 | 33 | $X^2$ |
| 375 | 54 | ) |
| 376 | 75 | - |
| 377 | 53 | ( |
| 378 | 06 | 6 |
| 379 | 93 | . |
| 380 | 06 | 6 |
| 381 | 07 | 7 |
| 382 | 06 | 6 |
| 383 | 07 | 7 |
| 384 | 52 | EE |
| 385 | 94 | +/- |
| 386 | 04 | 4 |
| 387 | 75 | - |
| 388 | 08 | 8 |
| 389 | 93 | . |
| 390 | 04 | 4 |
| 391 | 06 | 6 |
| 392 | 07 | 7 |
| 393 | 01 | 1 |
| 394 | 52 | EE |
| 395 | 94 | +/- |
| 396 | 06 | 6 |
| 397 | 65 | × |
| 398 | 43 | RCL |
| 399 | 02 | 02 |
| 400 | 85 | + |
| 401 | 01 | 1 |
| 402 | 93 | . |
| 403 | 00 | 0 |
| 404 | 05 | 5 |
| 405 | 00 | 0 |
| 406 | 01 | 1 |
| 407 | 52 | EE |
| 408 | 94 | +/- |
| 409 | 07 | 7 |
| 410 | 65 | × |
| 411 | 43 | RCL |
| 412 | 02 | 02 |
| 413 | 33 | $X^2$ |
| 414 | 75 | - |
| 415 | 03 | 3 |
| 416 | 93 | . |
| 417 | 06 | 6 |
| 418 | 03 | 3 |
| 419 | 08 | 8 |
| 420 | 02 | 2 |
| 421 | 52 | EE |
| 422 | 94 | +/- |
| 423 | 01 | 1 |
| 424 | 00 | 0 |
| 425 | 65 | × |
| 426 | 43 | RCL |
| 427 | 02 | 02 |
| 428 | 45 | $Y^X$ |
| 429 | 03 | 3 |
| 430 | 85 | + |
| 431 | 03 | 3 |
| 432 | 93 | . |
| 433 | 07 | 7 |
| 434 | 08 | 8 |
| 435 | 02 | 2 |
| 436 | 08 | 8 |
| 437 | 52 | EE |
| 438 | 94 | +/- |
| 439 | 01 | 1 |
| 440 | 03 | 3 |
| 441 | 65 | × |
| 442 | 43 | RCL |
| 443 | 02 | 02 |
| 444 | 45 | $Y^X$ |
| 445 | 04 | 4 |
| 446 | 54 | ) |
| 447 | 65 | × |
| 448 | 53 | ( |
| 449 | 43 | RCL |

```
450  06  06
451  45  Y^X
452  03   3
453  54   )
454  95   =
455  42  STO
456  07  07
457  65   ×
458  01   1
459  00   0
460  00   0
461  00   0
462  95   =
463  22  INV
464  52  EE
465  59  INT
466  55   ÷
467  01   1
468  00   0
469  00   0
470  00   0
471  95   =
472  91  R/S
473  43  RCL
474  07  07
475  75   -
476  53   (
477  53   (
478  06   6
479  00   0
480  75   -
481  43  RCL
482  03  03
483  54   )
484  65   ×
485  53   (
486  02   2
487  65   ×
488  43  RCL
489  07  07
490  54   )
491  55   ÷
492  01   1
493  02   2
494  00   0
495  00   0
496  54   )
497  95   =
498  42  STO
499  08  08
500  53   (
501  53   (
502  07   7
503  01   1
504  00   0
505  54   )
506  65   ×
507  53   (
508  43  RCL
509  08  08
510  75   -
511  93   .
512  01   1
513  04   4
514  54   )
515  85   +
516  01   1
517  00   0
518  00   0
519  75   -
520  43  RCL
521  04  04
522  54   )
523  95   =
524  42  STO
525  09  09
526  59  INT
527  91  R/S
528  43  RCL
529  09  09
530  35  1/X
531  65   ×
532  43  RCL
533  05  05
534  65   ×
535  06   6
536  00   0
537  95   =
538  65   ×
539  01   1
540  00   0
541  95   =
542  59  INT
543  55   ÷
544  01   1
545  00   0
546  95   =
547  91  R/S
```

USER INFORMATION FOR PROGRAM 4

Program: Maximum Range Fuel Required at Constant Altitude

Number of Steps: 439

Computation Time: 16 seconds

| STEP | ENTER | PRESS KEY | DISPLAY |
| --- | --- | --- | --- |
| 1 | gross weight (lbs.) | A | gross weight/1000 |
| 2 | altitude (ft.) | B | altitude/1000 |
| 3 | drag count | C | drag count |
| 4 | true air speed (kts.) | 2nd,D | true airspeed |
| 5 | time (minutes) | 2nd,E | (lb.fuel required/ nautical miles) |
| 6 | --- | R/S | fuel flow required |
| 7 | --- | R/S | fuel required |

| | | |
|---|---|---|
| 000 | 76 | LBL |
| 001 | 11 | A |
| 002 | 55 | ÷ |
| 003 | 01 | 1 |
| 004 | 00 | 0 |
| 005 | 00 | 0 |
| 006 | 00 | 0 |
| 007 | 95 | = |
| 008 | 42 | STO |
| 009 | 00 | 00 |
| 010 | 91 | R/S |
| 011 | 76 | LBL |
| 012 | 12 | B |
| 013 | 55 | ÷ |
| 014 | 01 | 1 |
| 015 | 00 | 0 |
| 016 | 00 | 0 |
| 017 | 00 | 0 |
| 018 | 95 | = |
| 019 | 42 | STO |
| 020 | 01 | 01 |
| 021 | 91 | R/S |
| 022 | 76 | LBL |
| 023 | 13 | C |
| 024 | 42 | STO |
| 025 | 02 | 02 |
| 026 | 91 | R/S |
| 027 | 76 | LBL |
| 028 | 19 | D' |
| 029 | 42 | STO |
| 030 | 03 | 03 |
| 031 | 91 | R/S |
| 032 | 76 | LBL |
| 033 | 10 | E' |
| 034 | 42 | STO |
| 035 | 04 | 04 |
| 036 | 53 | ( |
| 037 | 04 | 4 |
| 038 | 93 | . |
| 039 | 05 | 5 |
| 040 | 04 | 4 |
| 041 | 75 | - |
| 042 | 93 | . |
| 043 | 01 | 1 |
| 044 | 06 | 6 |
| 045 | 04 | 4 |
| 046 | 04 | 4 |
| 047 | 04 | 4 |
| 048 | 65 | × |
| 049 | 43 | RCL |
| 050 | 01 | 01 |
| 051 | 85 | + |
| 052 | 93 | . |
| 053 | 00 | 0 |
| 054 | 00 | 0 |
| 055 | 03 | 3 |
| 056 | 03 | 3 |
| 057 | 09 | 9 |
| 058 | 03 | 3 |
| 059 | 02 | 2 |
| 060 | 65 | × |
| 061 | 43 | RCL |
| 062 | 01 | 01 |
| 063 | 33 | X² |
| 064 | 75 | - |
| 065 | 01 | 1 |
| 066 | 93 | . |
| 067 | 00 | 0 |
| 068 | 02 | 2 |
| 069 | 08 | 8 |
| 070 | 03 | 3 |
| 071 | 52 | EE |
| 072 | 94 | +/- |
| 073 | 04 | 4 |
| 074 | 65 | × |
| 075 | 43 | RCL |
| 076 | 01 | 01 |
| 077 | 45 | Yˣ |
| 078 | 03 | 3 |
| 079 | 85 | + |
| 080 | 01 | 1 |
| 081 | 93 | . |
| 082 | 09 | 9 |
| 083 | 02 | 2 |
| 084 | 06 | 6 |
| 085 | 52 | EE |
| 086 | 94 | +/- |
| 087 | 06 | 6 |
| 088 | 65 | × |
| 089 | 43 | RCL |
| 090 | 01 | 01 |
| 091 | 45 | Yˣ |
| 092 | 04 | 4 |
| 093 | 75 | - |
| 094 | 01 | 1 |
| 095 | 93 | . |
| 096 | 03 | 3 |
| 097 | 07 | 7 |
| 098 | 05 | 5 |
| 099 | 07 | 7 |
| 100 | 52 | EE |
| 101 | 94 | +/- |
| 102 | 08 | 8 |
| 103 | 65 | × |
| 104 | 43 | RCL |
| 105 | 01 | 01 |
| 106 | 45 | Yˣ |
| 107 | 05 | 5 |
| 108 | 54 | ) |
| 109 | 85 | + |
| 110 | 53 | ( |
| 111 | 03 | 3 |
| 112 | 93 | . |
| 113 | 02 | 2 |
| 114 | 03 | 3 |
| 115 | 52 | EE |
| 116 | 94 | +/- |
| 117 | 09 | 9 |
| 118 | 75 | - |
| 119 | 03 | 3 |
| 120 | 93 | . |
| 121 | 06 | 6 |
| 122 | 06 | 6 |
| 123 | 06 | 6 |
| 124 | 04 | 4 |
| 125 | 52 | EE |
| 126 | 94 | +/- |
| 127 | 03 | 3 |
| 128 | 65 | × |
| 129 | 43 | RCL |
| 130 | 01 | 01 |
| 131 | 85 | + |
| 132 | 08 | 8 |
| 133 | 93 | . |
| 134 | 09 | 9 |
| 135 | 03 | 3 |
| 136 | 03 | 3 |
| 137 | 08 | 8 |
| 138 | 52 | EE |
| 139 | 94 | +/- |
| 140 | 04 | 4 |
| 141 | 65 | × |
| 142 | 43 | RCL |
| 143 | 01 | 01 |
| 144 | 33 | X² |
| 145 | 75 | - |
| 146 | 05 | 5 |
| 147 | 93 | . |
| 148 | 05 | 5 |
| 149 | 09 | 9 |

```
150  03  3
151  09  9
152  52  EE
153  94  +/-
154  05  5
155  65  ×
156  43  RCL
157  01  01
158  45  Yˣ
159  03  3
160  85  +
161  01  1
162  93  .
163  04  4
164  05  5
165  09  9
166  03  3
167  52  EE
168  94  +/-
169  06  6
170  65  ×
171  43  RCL
172  01  01
173  45  Yˣ
174  04  4
175  75  -
176  01  1
177  93  .
178  03  3
179  02  2
180  08  8
181  01  1
182  52  EE
183  94  +/-
184  08  8
185  65  ×
186  43  RCL
187  01  01
188  45  Yˣ
189  05  5
190  54  )
191  65  ×
192  43  RCL
193  00  00
194  85  +
195  53  (
196  06  6
197  52  EE
198  94  +/-
199  04  4
200  85  +
201  01  1
202  93  .
203  01  1
204  02  2
205  00  0
206  03  3
207  52  EE
208  94  +/-
209  04  4
210  65  ×
211  43  RCL
212  01  01
213  75  -
214  02  2
215  93  .
216  03  3
217  03  3
218  05  5
219  08  8
220  52  EE
221  94  +/-
222  05  5
223  65  ×
224  43  RCL
225  01  01
226  33  X²
227  85  +
228  01  1
229  93  .
230  04  4
231  05  5
232  03  3
233  06  6
234  52  EE
235  94  +/-
236  06  6
237  65  ×
238  43  RCL
239  01  01
240  45  Yˣ
241  03  3
242  75  -
243  03  3
244  93  .
245  07  7
246  01  1
247  04  4
248  04  4
249  52  EE
250  94  +/-
251  08  8
252  65  ×
253  43  RCL
254  01  01
255  45  Yˣ
256  04  4
257  85  +
258  03  3
259  93  .
260  03  3
261  03  3
262  03  3
263  04  4
264  52  EE
265  94  +/-
266  01  1
267  00  0
268  65  ×
269  43  RCL
270  01  01
271  45  Yˣ
272  05  5
273  54  )
274  65  ×
275  43  RCL
276  00  00
277  33  X²
278  95  =
279  42  STO
280  05  05
281  01  1
282  93  .
283  04  4
284  02  2
285  05  5
286  01  1
287  52  EE
288  94  +/-
289  01  1
290  00  0
291  65  ×
292  43  RCL
293  02  02
294  45  Yˣ
295  04  4
296  75  -
297  02  2
298  93  .
299  03  3
```

```
300   05   5
301   01   1
302   06   6
303   52  EE
304   94  +/-
305   07   7
306   65   ×
307   43  RCL
308   02   02
309   45  Y^X
310   03   3
311   85   +
312   09   9
313   93   .
314   07   7
315   02   2
316   09   9
317   09   9
318   52  EE
319   94  +/-
320   05   5
321   65   ×
322   43  RCL
323   02   02
324   33  X²
325   75   -
326   02   2
327   93   .
328   05   5
329   03   3
330   09   9
331   09   9
332   52  EE
333   94  +/-
334   03   3
335   65   ×
336   43  RCL
337   02   02
338   85   +
339   53   (
340   02   2
341   85   +
342   93   .
343   00   0
344   00   0
345   04   4
346   02   2
347   03   3
348   08   8
349   08   8
350   65   ×
351   43  RCL
352   02   02
353   85   +
354   01   1
355   93   .
356   02   2
357   03   3
358   02   2
359   06   6
360   52  EE
361   94  +/-
362   05   5
363   65   ×
364   43  RCL
365   02   02
366   33  X²
367   75   -
368   01   1
369   93   .
370   00   0
371   02   2
372   09   9
373   08   8
374   52  EE
375   94  +/-
376   07   7
377   65   ×
378   43  RCL
379   02   02
380   45  Y^X
381   03   3
382   85   +
383   01   1
384   93   .
385   07   7
386   02   2
387   07   7
388   07   7
389   52  EE
390   94  +/-
391   01   1
392   00   0
393   65   ×
394   43  RCL
395   02   02
396   45  Y^X
397   04   4
398   54   )
399   65   ×
400   43  RCL
401   05   05
402   95   =
403   42  STO
404   09   09
405   65   ×
406   01   1
407   52  EE
408   03   3
409   95   =
410   59  INT
411   55   ÷
412   01   1
413   52  EE
414   03   3
415   95   =
416   22  INV
417   52  EE
418   91  R/S
419   43  RCL
420   09   09
421   65   ×
422   43  RCL
423   03   03
424   95   =
425   42  STO
426   09   09
427   59  INT
428   91  R/S
429   43  RCL
430   09   09
431   65   ×
432   43  RCL
433   04   04
434   55   ÷
435   06   6
436   00   0
437   95   =
438   59  INT
439   91  R/S
```

USER INFORMATION FOR PROGRAM 5

Program: Military Climb Schedule

Number of Steps: 195

Computation Time: 3 seconds

| STEP | ENTER | PRESS KEY | DISPLAY |
|---|---|---|---|
| 1 | gross weight (lbs.) | A | gross weight/1000 |
| 2 | altitude (ft.) | B | altitude |
| 3 | drag count | C | drag count |
| 4 | temperature (°C) | E | indicated airspeed (kts. below 20000 ft.) |
| 5 | --- | R/S | mach number (above 20000 ft.) |

```
000  76  LBL
001  11  A
002  42  STO
003  01  01
004  91  R/S
005  76  LBL
006  12  B
007  42  STO
008  02  02
009  91  R/S
010  76  LBL
011  13  C
012  42  STO
013  00  00
014  91  R/S
015  76  LBL
016  15  E
017  42  STO
018  03  03
019  25  CLR
020  04  4
021  00  0
022  05  5
023  93  .
024  05  5
025  08  8
026  75  -
027  93  .
028  07  7
029  09  9
030  00  0
031  07  7
032  05  5
033  65  ×
034  43  RCL
035  00  00
036  85  +
037  93  .
038  00  0
039  00  0
040  01  1
041  01  1
042  03  3
043  08  8
044  02  2
045  65  ×
046  43  RCL
047  00  00
048  33  X^2
049  75  -
050  04  4
051  93  .
052  01  1
053  00  0
054  01  1
055  08  8
056  52  EE
057  94  +/-
058  07  7
059  65  ×
060  43  RCL
061  00  00
062  45  Y^x
063  03  3
064  95  =
065  22  INV
066  52  EE
067  59  INT
068  91  R/S
069  25  CLR
070  93  .
071  08  8
072  06  6
073  75  -
074  02  2
075  93  .
076  01  1
077  06  6
078  03  3
079  04  4
080  52  EE
081  94  +/-
082  03  3
083  65  ×
084  43  RCL
085  00  00
086  85  +
087  07  7
088  93  .
089  06  6
090  05  5
091  08  8
092  02  2
093  52  EE
094  94  +/-
095  05  5
096  65  ×
097  43  RCL
098  00  00
099  33  X^2
100  75  -
101  01  1
102  93  .
103  01  1
104  03  3
105  04  4
106  04  4
107  52  EE
108  94  +/-
109  06  6
110  65  ×
111  43  RCL
112  00  00
113  45  Y^x
114  03  3
115  85  +
116  07  7
117  93  .
118  02  2
119  01  1
120  02  2
121  05  5
122  52  EE
123  94  +/-
124  09  9
125  65  ×
126  43  RCL
127  00  00
128  45  Y^x
129  04  4
130  75  -
131  02  2
132  93  .
133  03  3
134  00  0
135  03  3
136  05  5
137  52  EE
138  94  +/-
139  01  1
140  01  1
141  65  ×
142  43  RCL
143  00  00
144  45  Y^x
145  05  5
146  85  +
147  03  3
148  93  .
149  06  6
```

| | | |
|---|---|---|
| 150 | 05 | 5 |
| 151 | 08 | 8 |
| 152 | 08 | 8 |
| 153 | 52 | EE |
| 154 | 94 | +/- |
| 155 | 01 | 1 |
| 156 | 04 | 4 |
| 157 | 65 | × |
| 158 | 43 | RCL |
| 159 | 00 | 00 |
| 160 | 45 | Y× |
| 161 | 06 | 6 |
| 162 | 75 | - |
| 163 | 02 | 2 |
| 164 | 93 | . |
| 165 | 03 | 3 |
| 166 | 00 | 0 |
| 167 | 06 | 6 |
| 168 | 02 | 2 |
| 169 | 52 | EE |
| 170 | 94 | +/- |
| 171 | 01 | 1 |
| 172 | 07 | 7 |
| 173 | 65 | × |
| 174 | 43 | RCL |
| 175 | 00 | 00 |
| 176 | 45 | Y× |
| 177 | 07 | 7 |
| 178 | 95 | = |
| 179 | 65 | × |
| 180 | 01 | 1 |
| 181 | 00 | 0 |
| 182 | 00 | 0 |
| 183 | 00 | 0 |
| 184 | 95 | = |
| 185 | 22 | INV |
| 186 | 52 | EE |
| 187 | 59 | INT |
| 188 | 95 | = |
| 189 | 55 | ÷ |
| 190 | 01 | 1 |
| 191 | 00 | 0 |
| 192 | 00 | 0 |
| 193 | 00 | 0 |
| 194 | 95 | = |
| 195 | 91 | R/S |

USER INFORMATION FOR PROGRAM 6

Program: Takeoff Airspeed

Number of Steps: 265

Computation Time: 9 seconds

| STEP | ENTER | PRESS KEY | DISPLAY |
|---|---|---|---|
| 1 | gross weight (lbs.) | A | gross weight |
| 2 | flap position (degrees) | 2nd,A | flap position |
| 3 | center of gravity (%) | 2nd,B | takeoff airspeed (kts) |

```
000  76  LBL
001  11  A
002  42  STO
003  00  00
004  91  R/S
005  76  LBL
006  16  A'
007  42  STO
008  02  02
009  91  R/S
010  76  LBL
011  17  B'
012  42  STO
013  01  01
014  53  (
015  05  5
016  04  4
017  93  .
018  00  0
019  02  2
020  03  3
021  65  ×
022  03  3
023  93  .
024  04  4
025  07  7
026  08  8
027  07  7
028  52  EE
029  94  +/-
030  03  3
031  65  ×
032  43  RCL
033  00  00
034  75  -
035  01  1
036  93  .
037  09  9
038  04  4
039  07  7
040  05  5
041  52  EE
042  94  +/-
043  08  8
044  65  ×
045  43  RCL
046  00  00
047  33  X²
048  54  )
049  85  +
050  53  (
051  53  (
052  02  2
053  06  6
054  75  -
055  43  RCL
056  01  01
057  54  )
058  55  ÷
059  02  2
060  54  )
061  95  =
062  42  STO
063  03  03
064  25  CLR
065  75  -
066  53  (
067  01  1
068  93  .
069  09  9
070  01  1
071  07  7
072  01  1
073  52  EE
074  03  3
075  75  -
076  06  6
077  01  1
078  93  .
079  06  6
080  00  0
081  04  4
082  65  ×
083  43  RCL
084  03  03
085  85  +
086  93  .
087  07  7
088  00  0
089  03  3
090  04  4
091  08  8
092  65  ×
093  43  RCL
094  03  03
095  33  X²
096  75  -
097  03  3
098  93  .
099  05  5
100  06  6
101  06  6
102  01  1
103  52  EE
104  94  +/-
105  03  3
106  65  ×
107  43  RCL
108  03  03
109  45  YX
110  03  3
111  85  +
112  06  6
113  93  .
114  06  6
115  05  5
116  07  7
117  08  8
118  52  EE
119  94  +/-
120  06  6
121  65  ×
122  43  RCL
123  03  03
124  45  YX
125  04  4
126  54  )
127  85  +
128  53  (
129  07  7
130  06  6
131  93  .
132  08  8
133  02  2
134  04  4
135  75  -
136  02  2
137  93  .
138  04  4
139  05  5
140  01  1
141  07  7
142  65  ×
143  43  RCL
144  03  03
145  85  +
146  02  2
147  93  .
148  08  8
149  07  7
```

| | | |
|---|---|---|
| 150 | 07 | 7 |
| 151 | 09 | 9 |
| 152 | 52 | EE |
| 153 | 94 | +/- |
| 154 | 02 | 2 |
| 155 | 65 | × |
| 156 | 43 | RCL |
| 157 | 03 | 03 |
| 158 | 33 | $X^2$ |
| 159 | 75 | - |
| 160 | 01 | 1 |
| 161 | 93 | . |
| 162 | 04 | 4 |
| 163 | 07 | 7 |
| 164 | 05 | 5 |
| 165 | 03 | 3 |
| 166 | 52 | EE |
| 167 | 94 | +/- |
| 168 | 04 | 4 |
| 169 | 65 | × |
| 170 | 43 | RCL |
| 171 | 03 | 03 |
| 172 | 45 | $Y^X$ |
| 173 | 03 | 3 |
| 174 | 85 | + |
| 175 | 02 | 2 |
| 176 | 93 | . |
| 177 | 07 | 7 |
| 178 | 08 | 8 |
| 179 | 07 | 7 |
| 180 | 02 | 2 |
| 181 | 52 | EE |
| 182 | 94 | +/- |
| 183 | 07 | 7 |
| 184 | 65 | × |
| 185 | 43 | RCL |
| 186 | 03 | 03 |
| 187 | 45 | $Y^X$ |
| 188 | 04 | 4 |
| 189 | 54 | ) |
| 190 | 65 | × |
| 191 | 43 | RCL |
| 192 | 02 | 02 |
| 193 | 75 | - |
| 194 | 53 | ( |
| 195 | 93 | . |
| 196 | 07 | 7 |
| 197 | 02 | 2 |
| 198 | 02 | 2 |
| 199 | 03 | 3 |
| 200 | 09 | 9 |
| 201 | 75 | - |
| 202 | 93 | . |
| 203 | 00 | 0 |
| 204 | 02 | 2 |
| 205 | 03 | 3 |
| 206 | 04 | 4 |
| 207 | 01 | 1 |
| 208 | 05 | 5 |
| 209 | 65 | × |
| 210 | 43 | RCL |
| 211 | 03 | 03 |
| 212 | 85 | + |
| 213 | 02 | 2 |
| 214 | 93 | . |
| 215 | 07 | 7 |
| 216 | 09 | 9 |
| 217 | 08 | 8 |
| 218 | 52 | EE |
| 219 | 94 | +/- |
| 220 | 04 | 4 |
| 221 | 65 | × |
| 222 | 43 | RCL |
| 223 | 03 | 03 |
| 224 | 33 | $X^2$ |
| 225 | 75 | - |
| 226 | 01 | 1 |
| 227 | 93 | . |
| 228 | 04 | 4 |
| 229 | 05 | 5 |
| 230 | 09 | 9 |
| 231 | 06 | 6 |
| 232 | 52 | EE |
| 233 | 94 | +/- |
| 234 | 06 | 6 |
| 235 | 65 | × |
| 236 | 43 | RCL |
| 237 | 03 | 03 |
| 238 | 45 | $Y^X$ |
| 239 | 03 | 3 |
| 240 | 85 | + |
| 241 | 02 | 2 |
| 242 | 93 | . |
| 243 | 08 | 8 |
| 244 | 00 | 0 |
| 245 | 07 | 7 |
| 246 | 52 | EE |
| 247 | 94 | +/- |
| 248 | 09 | 9 |
| 249 | 65 | × |
| 250 | 43 | RCL |
| 251 | 03 | 03 |
| 252 | 45 | $Y^X$ |
| 253 | 04 | 4 |
| 254 | 54 | ) |
| 255 | 65 | × |
| 256 | 53 | ( |
| 257 | 43 | RCL |
| 258 | 02 | 02 |
| 259 | 33 | $X^2$ |
| 260 | 54 | ) |
| 261 | 95 | = |
| 262 | 22 | INV |
| 263 | 52 | EE |
| 264 | 59 | INT |
| 265 | 91 | R/S |

## USER INFORMATION FOR PROGRAM 7

Program: Maximum Refusal Speed

Number of Steps: 716

Computation Time: 26 seconds

| STEP | ENTER | PRESS KEY | DISPLAY |
|---|---|---|---|
| 1 | gross weight (lbs.) | A | gross weight/1000 |
| 2 | runway altitude (ft.) | B | runway altitude |
| 3 | temperature (°C) | E | temperature |
| 4 | runway length (ft.) | 2nd,C | maximum refusal speed |

```
000  76  LBL
001  12   B
002  42  STO
003  00   00
004  91  R/S
005  76  LBL
006  15   E
007  42  STO
008  01   01
009  91  R/S
010  76  LBL
011  11   A
012  55   ÷
013  01   1
014  00   0
015  00   0
016  00   0
017  95   =
018  42  STO
019  02   02
020  91  R/S
021  76  LBL
022  18  C'
023  55   ÷
024  01   1
025  00   0
026  00   0
027  00   0
028  95   =
029  42  STO
030  03   03
031  53   (
032  01   1
033  03   3
034  93   .
035  00   0
036  08   8
037  06   6
038  75   -
039  93   .
040  00   0
041  00   0
042  00   0
043  01   1
044  07   7
045  01   1
046  01   1
047  03   3
048  65   ×
049  43  RCL
050  00   00
051  75   -
052  02   2
053  93   .
054  00   0
055  06   6
056  05   5
057  05   5
058  52  EE
059  94  +/-
060  07   7
061  65   ×
062  43  RCL
063  00   00
064  33  X²
065  85   +
066  03   3
067  93   .
068  06   6
069  08   8
070  06   6
071  01   1
072  52  EE
073  94  +/-
074  01   1
075  01   1
076  65   ×
077  43  RCL
078  00   00
079  45  Y^X
080  03   3
081  75   -
082  02   2
083  93   .
084  04   4
085  01   1
086  05   5
087  06   6
088  52  EE
089  94  +/-
090  01   1
091  05   5
092  65   ×
093  43  RCL
094  00   00
095  45  Y^X
096  04   4
097  54   )
098  75   -
099  53   (
100  93   .
101  00   0
102  04   4
103  05   5
104  06   6
105  03   3
106  85   +
107  07   7
108  93   .
109  08   8
110  09   9
111  03   3
112  01   1
113  52  EE
114  94  +/-
115  06   6
116  65   ×
117  43  RCL
118  00   00
119  75   -
120  03   3
121  93   .
122  07   7
123  05   5
124  04   4
125  05   5
126  52  EE
127  94  +/-
128  09   9
129  65   ×
130  43  RCL
131  00   00
132  33  X²
133  85   +
134  09   9
135  93   .
136  07   7
137  00   0
138  08   8
139  08   8
140  52  EE
141  94  +/-
142  01   1
143  03   3
144  65   ×
145  43  RCL
146  00   00
147  45  Y^X
148  03   3
149  75   -
```

| | | |
|---|---|---|
| 150 | 06 | 6 |
| 151 | 93 | . |
| 152 | 09 | 9 |
| 153 | 09 | 9 |
| 154 | 07 | 7 |
| 155 | 52 | EE |
| 156 | 94 | +/- |
| 157 | 01 | 1 |
| 158 | 07 | 7 |
| 159 | 65 | × |
| 160 | 43 | RCL |
| 161 | 00 | 00 |
| 162 | 45 | $Y^X$ |
| 163 | 04 | 4 |
| 164 | 54 | ) |
| 165 | 65 | × |
| 166 | 53 | ( |
| 167 | 43 | RCL |
| 168 | 01 | 01 |
| 169 | 54 | ) |
| 170 | 75 | - |
| 171 | 53 | ( |
| 172 | 93 | . |
| 173 | 00 | 0 |
| 174 | 00 | 0 |
| 175 | 01 | 1 |
| 176 | 03 | 3 |
| 177 | 01 | 1 |
| 178 | 07 | 7 |
| 179 | 85 | + |
| 180 | 08 | 8 |
| 181 | 93 | . |
| 182 | 02 | 2 |
| 183 | 05 | 5 |
| 184 | 05 | 5 |
| 185 | 08 | 8 |
| 186 | 52 | EE |
| 187 | 94 | +/- |
| 188 | 07 | 7 |
| 189 | 65 | × |
| 190 | 43 | RCL |
| 191 | 00 | 00 |
| 192 | 75 | - |
| 193 | 04 | 4 |
| 194 | 93 | . |
| 195 | 00 | 0 |
| 196 | 07 | 7 |
| 197 | 03 | 3 |
| 198 | 09 | 9 |
| 199 | 02 | 2 |
| 200 | 52 | EE |
| 201 | 94 | +/- |
| 202 | 01 | 1 |
| 203 | 00 | 0 |
| 204 | 65 | × |
| 205 | 43 | RCL |
| 206 | 00 | 00 |
| 207 | 33 | $X^2$ |
| 208 | 85 | + |
| 209 | 08 | 8 |
| 210 | 93 | . |
| 211 | 05 | 5 |
| 212 | 04 | 4 |
| 213 | 08 | 8 |
| 214 | 08 | 8 |
| 215 | 52 | EE |
| 216 | 94 | +/- |
| 217 | 01 | 1 |
| 218 | 04 | 4 |
| 219 | 65 | × |
| 220 | 43 | RCL |
| 221 | 00 | 00 |
| 222 | 45 | $Y^X$ |
| 223 | 03 | 3 |
| 224 | 75 | - |
| 225 | 05 | 5 |
| 226 | 93 | . |
| 227 | 04 | 4 |
| 228 | 09 | 9 |
| 229 | 06 | 6 |
| 230 | 04 | 4 |
| 231 | 52 | EE |
| 232 | 94 | +/- |
| 233 | 01 | 1 |
| 234 | 08 | 8 |
| 235 | 65 | × |
| 236 | 43 | RCL |
| 237 | 00 | 00 |
| 238 | 45 | $Y^X$ |
| 239 | 04 | 4 |
| 240 | 54 | ) |
| 241 | 65 | × |
| 242 | 53 | ( |
| 243 | 43 | RCL |
| 244 | 01 | 01 |
| 245 | 33 | $X^2$ |
| 246 | 54 | ) |
| 247 | 75 | - |
| 248 | 53 | ( |
| 249 | 01 | 1 |
| 250 | 93 | . |
| 251 | 09 | 9 |
| 252 | 00 | 0 |
| 253 | 09 | 9 |
| 254 | 07 | 7 |
| 255 | 52 | EE |
| 256 | 94 | +/- |
| 257 | 05 | 5 |
| 258 | 75 | - |
| 259 | 01 | 1 |
| 260 | 93 | . |
| 261 | 03 | 3 |
| 262 | 06 | 6 |
| 263 | 07 | 7 |
| 264 | 01 | 1 |
| 265 | 52 | EE |
| 266 | 94 | +/- |
| 267 | 08 | 8 |
| 268 | 65 | × |
| 269 | 43 | RCL |
| 270 | 00 | 00 |
| 271 | 85 | + |
| 272 | 09 | 9 |
| 273 | 93 | . |
| 274 | 04 | 4 |
| 275 | 06 | 6 |
| 276 | 09 | 9 |
| 277 | 04 | 4 |
| 278 | 52 | EE |
| 279 | 94 | +/- |
| 280 | 01 | 1 |
| 281 | 02 | 2 |
| 282 | 65 | × |
| 283 | 43 | RCL |
| 284 | 00 | 00 |
| 285 | 33 | $X^2$ |
| 286 | 75 | - |
| 287 | 02 | 2 |
| 288 | 93 | . |
| 289 | 00 | 0 |
| 290 | 04 | 4 |
| 291 | 03 | 3 |
| 292 | 04 | 4 |
| 293 | 52 | EE |
| 294 | 94 | +/- |
| 295 | 01 | 1 |
| 296 | 05 | 5 |
| 297 | 65 | × |
| 298 | 43 | RCL |
| 299 | 00 | 00 |

```
300  45  Y×
301  03   3
302  85   +
303  01   1
304  93   .
305  04   4
306  06   6
307  01   1
308  07   7
309  52  EE
310  94  +/-
311  01   1
312  09   9
313  65   ×
314  43  RCL
315  00   00
316  45  Y×
317  04   4
318  54   )
319  65   ×
320  53   (
321  43  RCL
322  01   01
323  45  Y×
324  03   3
325  54   )
326  95   =
327  65   ×
328  93   .
329  05   5
330  06   6
331  06   6
332  85   +
333  01   1
334  93   .
335  09   9
336  09   9
337  07   7
338  03   3
339  95   =
340  42  STO
341  04   04
342  53   (
343  04   4
344  03   3
345  93   .
346  00   0
347  01   1
348  94  +/-
349  85   +
350  06   6
351  93   .
352  07   7
353  06   6
354  01   1
355  65   ×
356  43  RCL
357  02   02
358  75   -
359  93   .
360  03   3
361  05   5
362  01   1
363  05   5
364  09   9
365  65   ×
366  43  RCL
367  02   02
368  33  X²
369  85   +
370  93   .
371  00   0
372  00   0
373  08   8
374  00   0
375  05   5
376  04   4
377  05   5
378  65   ×
379  43  RCL
380  02   02
381  45  Y×
382  03   3
383  75   -
384  06   6
385  93   .
386  07   7
387  07   7
388  06   6
389  09   9
390  52  EE
391  94  +/-
392  05   5
393  65   ×
394  43  RCL
395  02   02
396  45  Y×
397  04   4
398  54   )
399  85   +
400  53   (
401  02   2
402  06   6
403  93   .
404  03   3
405  01   1
406  02   2
407  75   -
408  03   3
409  93   .
410  08   8
411  03   3
412  08   8
413  02   2
414  65   ×
415  43  RCL
416  02   02
417  85   +
418  93   .
419  93   .
420  02   2
421  00   0
422  03   3
423  02   2
424  06   6
425  65   ×
426  43  RCL
427  02   02
428  33  X²
429  75   -
430  93   .
431  00   0
432  00   0
433  04   4
434  07   7
435  00   0
436  02   2
437  02   2
438  65   ×
439  43  RCL
440  02   02
441  45  Y×
442  03   3
443  85   +
444  03   3
445  93   .
446  09   9
447  09   9
448  04   4
449  52  EE
```

| | | |
|---|---|---|
| 450 | 94 | +/- |
| 451 | 05 | 5 |
| 452 | 65 | × |
| 453 | 43 | RCL |
| 454 | 02 | 02 |
| 455 | 45 | $Y^X$ |
| 456 | 04 | 4 |
| 457 | 54 | ) |
| 458 | 65 | × |
| 459 | 43 | RCL |
| 460 | 04 | 04 |
| 461 | 75 | - |
| 462 | 53 | ( |
| 463 | 04 | 4 |
| 464 | 93 | . |
| 465 | 09 | 9 |
| 466 | 06 | 6 |
| 467 | 03 | 3 |
| 468 | 09 | 9 |
| 469 | 75 | - |
| 470 | 93 | . |
| 471 | 07 | 7 |
| 472 | 02 | 2 |
| 473 | 07 | 7 |
| 474 | 02 | 2 |
| 475 | 03 | 3 |
| 476 | 65 | × |
| 477 | 43 | RCL |
| 478 | 02 | 02 |
| 479 | 85 | + |
| 480 | 93 | . |
| 481 | 00 | 0 |
| 482 | 03 | 3 |
| 483 | 08 | 8 |
| 484 | 07 | 7 |
| 485 | 02 | 2 |
| 486 | 01 | 1 |
| 487 | 65 | × |
| 488 | 43 | RCL |
| 489 | 02 | 02 |
| 490 | 33 | $X^2$ |
| 491 | 75 | - |
| 492 | 08 | 8 |
| 493 | 93 | . |
| 494 | 09 | 9 |
| 495 | 08 | 8 |
| 496 | 05 | 5 |
| 497 | 52 | EE |
| 498 | 94 | +/- |
| 499 | 04 | 4 |
| 500 | 65 | × |
| 501 | 43 | RCL |
| 502 | 02 | 02 |
| 503 | 45 | $Y^X$ |
| 504 | 03 | 3 |
| 505 | 85 | + |
| 506 | 07 | 7 |
| 507 | 93 | . |
| 508 | 06 | 6 |
| 509 | 03 | 3 |
| 510 | 08 | 8 |
| 511 | 52 | EE |
| 512 | 94 | +/- |
| 513 | 06 | 6 |
| 514 | 65 | × |
| 515 | 43 | RCL |
| 516 | 02 | 02 |
| 517 | 45 | $Y^X$ |
| 518 | 04 | 4 |
| 519 | 54 | ) |
| 520 | 65 | × |
| 521 | 53 | ( |
| 522 | 43 | RCL |
| 523 | 04 | 04 |
| 524 | 33 | $X^2$ |
| 525 | 54 | ) |
| 526 | 85 | + |
| 527 | 53 | ( |
| 528 | 93 | . |
| 529 | 03 | 3 |
| 530 | 00 | 0 |
| 531 | 02 | 2 |
| 532 | 08 | 8 |
| 533 | 08 | 8 |
| 534 | 75 | - |
| 535 | 93 | . |
| 536 | 00 | 0 |
| 537 | 04 | 4 |
| 538 | 04 | 4 |
| 539 | 08 | 8 |
| 540 | 05 | 5 |
| 541 | 05 | 5 |
| 542 | 65 | × |
| 543 | 43 | RCL |
| 544 | 02 | 02 |
| 545 | 85 | + |
| 546 | 93 | . |
| 547 | 00 | 0 |
| 548 | 00 | 0 |
| 549 | 02 | 2 |
| 550 | 03 | 3 |
| 551 | 09 | 9 |
| 552 | 02 | 2 |
| 553 | 01 | 1 |
| 554 | 65 | × |
| 555 | 43 | RCL |
| 556 | 02 | 02 |
| 557 | 33 | $X^2$ |
| 558 | 75 | - |
| 559 | 05 | 5 |
| 560 | 93 | . |
| 561 | 05 | 5 |
| 562 | 05 | 5 |
| 563 | 04 | 4 |
| 564 | 09 | 9 |
| 565 | 52 | EE |
| 566 | 94 | +/- |
| 567 | 05 | 5 |
| 568 | 65 | × |
| 569 | 53 | ( |
| 570 | 43 | RCL |
| 571 | 02 | 02 |
| 572 | 45 | $Y^X$ |
| 573 | 03 | 3 |
| 574 | 54 | ) |
| 575 | 85 | + |
| 576 | 04 | 4 |
| 577 | 93 | . |
| 578 | 07 | 7 |
| 579 | 02 | 2 |
| 580 | 01 | 1 |
| 581 | 07 | 7 |
| 582 | 52 | EE |
| 583 | 94 | +/- |
| 584 | 07 | 7 |
| 585 | 65 | × |
| 586 | 53 | ( |
| 587 | 43 | RCL |
| 588 | 02 | 02 |
| 589 | 45 | $Y^X$ |
| 590 | 04 | 4 |
| 591 | 54 | ) |
| 592 | 54 | ) |
| 593 | 65 | × |
| 594 | 53 | ( |
| 595 | 43 | RCL |
| 596 | 04 | 04 |
| 597 | 45 | $Y^X$ |
| 598 | 03 | 3 |
| 599 | 54 | ) |

```
600  95  =
601  65  ×
602  53  (
603  93  .
604  02  2
605  08  8
606  01  1
607  01  1
608  94  +/-
609  75  -
610  04  4
611  93  .
612  02  2
613  00  0
614  01  1
615  02  2
616  65  ×
617  43  RCL
618  03  03
619  85  +
620  93  .
621  07  7
622  00  0
623  03  3
624  07  7
625  07  7
626  65  ×
627  43  RCL
628  03  03
629  33  X²
630  75  -
631  93  .
632  00  0
633  05  5
634  08  8
635  06  6
636  09  9
637  03  3
638  65  ×
639  43  RCL
640  03  03
641  45  Y×
642  03  3
643  85  +
644  93  .
645  00  0
646  00  0
647  01  1
648  07  7
649  04  4
650  06  6
651  01  1
652  65  ×
653  43  RCL
654  03  03
655  45  Y×
656  04  4
657  54  )
658  75  -
659  01  1
660  01  1
661  93  .
662  04  4
663  01  1
664  02  2
665  85  +
666  06  6
667  02  2
668  93  .
669  01  1
670  08  8
671  05  5
672  65  ×
673  43  RCL
674  03  03
675  75  -
676  09  9
677  93  .
678  00  0
679  00  0
680  03  3
681  07  7
682  65  ×
683  43  RCL
684  03  03
685  33  X²
686  85  +
687  93  .
688  06  6
689  04  4
690  09  9
691  02  2
692  01  1
693  65  ×
694  43  RCL
695  03  03
696  45  Y×
697  03  3
698  75  -
699  93  .
700  00  0
701  01  1
702  07  7
703  04  4
704  05  5
705  05  5
706  65  ×
707  43  RCL
708  03  03
709  45  Y×
710  04  4
711  95  =
712  22  INV
713  52  EE
714  59  INT
715  95  =
716  91  R/S
```

USER INFORMATION FOR PROGRAM 8

Program: Optimum Endurance Altitude

Number of Steps: 229

Computation Time: 8 seconds

| STEP | ENTER | PRESS KEY | DISPLAY |
|---|---|---|---|
| 1 | gross weight (lbs.) | A | gross weight/1000 |
| 2 | drag count | C | optimum endurance altitude (ft.) |

| | | |
|---|---|---|
| 000 | 76 | LBL |
| 001 | 11 | A |
| 002 | 55 | ÷ |
| 003 | 01 | 1 |
| 004 | 00 | 0 |
| 005 | 00 | 0 |
| 006 | 00 | 0 |
| 007 | 95 | = |
| 008 | 42 | STO |
| 009 | 00 | 00 |
| 010 | 91 | R/S |
| 011 | 76 | LBL |
| 012 | 13 | C |
| 013 | 42 | STO |
| 014 | 01 | 01 |
| 015 | 25 | CLR |
| 016 | 05 | 5 |
| 017 | 05 | 5 |
| 018 | 93 | . |
| 019 | 03 | 3 |
| 020 | 03 | 3 |
| 021 | 03 | 3 |
| 022 | 03 | 3 |
| 023 | 85 | + |
| 024 | 93 | . |
| 025 | 00 | 0 |
| 026 | 07 | 7 |
| 027 | 03 | 3 |
| 028 | 00 | 0 |
| 029 | 07 | 7 |
| 030 | 06 | 6 |
| 031 | 65 | × |
| 032 | 43 | RCL |
| 033 | 01 | 01 |
| 034 | 75 | - |
| 035 | 09 | 9 |
| 036 | 93 | . |
| 037 | 07 | 7 |
| 038 | 08 | 8 |
| 039 | 03 | 3 |
| 040 | 06 | 6 |
| 041 | 52 | EE |
| 042 | 94 | +/- |
| 043 | 04 | 4 |
| 044 | 65 | × |
| 045 | 43 | RCL |
| 046 | 01 | 01 |
| 047 | 33 | $X^2$ |
| 048 | 85 | + |
| 049 | 03 | 3 |
| 050 | 93 | . |
| 051 | 05 | 5 |
| 052 | 00 | 0 |
| 053 | 01 | 1 |
| 054 | 05 | 5 |
| 055 | 52 | EE |
| 056 | 94 | +/- |
| 057 | 06 | 6 |
| 058 | 65 | × |
| 059 | 43 | RCL |
| 060 | 01 | 01 |
| 061 | 45 | $Y^X$ |
| 062 | 03 | 3 |
| 063 | 75 | - |
| 064 | 03 | 3 |
| 065 | 93 | . |
| 066 | 09 | 9 |
| 067 | 07 | 7 |
| 068 | 08 | 8 |
| 069 | 02 | 2 |
| 070 | 52 | EE |
| 071 | 94 | +/- |
| 072 | 09 | 9 |
| 073 | 65 | × |
| 074 | 43 | RCL |
| 075 | 01 | 01 |
| 076 | 45 | $Y^X$ |
| 077 | 04 | 4 |
| 078 | 75 | - |
| 079 | 53 | ( |
| 080 | 01 | 1 |
| 081 | 93 | . |
| 082 | 01 | 1 |
| 083 | 85 | + |
| 084 | 08 | 8 |
| 085 | 93 | . |
| 086 | 00 | 0 |
| 087 | 05 | 5 |
| 088 | 09 | 9 |
| 089 | 07 | 7 |
| 090 | 52 | EE |
| 091 | 94 | +/- |
| 092 | 03 | 3 |
| 093 | 65 | × |
| 094 | 43 | RCL |
| 095 | 01 | 01 |
| 096 | 75 | - |
| 097 | 08 | 8 |
| 098 | 93 | . |
| 099 | 00 | 0 |
| 100 | 00 | 0 |
| 101 | 09 | 9 |
| 102 | 07 | 7 |
| 103 | 52 | EE |
| 104 | 94 | +/- |
| 105 | 05 | 5 |
| 106 | 65 | × |
| 107 | 43 | RCL |
| 108 | 01 | 01 |
| 109 | 33 | $X^2$ |
| 110 | 85 | + |
| 111 | 02 | 2 |
| 112 | 93 | . |
| 113 | 08 | 8 |
| 114 | 08 | 8 |
| 115 | 03 | 3 |
| 116 | 06 | 6 |
| 117 | 52 | EE |
| 118 | 94 | +/- |
| 119 | 07 | 7 |
| 120 | 65 | × |
| 121 | 43 | RCL |
| 122 | 01 | 01 |
| 123 | 45 | $Y^X$ |
| 124 | 03 | 3 |
| 125 | 75 | - |
| 126 | 03 | 3 |
| 127 | 93 | . |
| 128 | 03 | 3 |
| 129 | 00 | 0 |
| 130 | 03 | 3 |
| 131 | 02 | 2 |
| 132 | 52 | EE |
| 133 | 94 | +/- |
| 134 | 01 | 1 |
| 135 | 00 | 0 |
| 136 | 65 | × |
| 137 | 43 | RCL |
| 138 | 01 | 01 |
| 139 | 45 | $Y^X$ |
| 140 | 04 | 4 |
| 141 | 54 | ) |
| 142 | 65 | × |
| 143 | 43 | RCL |
| 144 | 00 | 00 |
| 145 | 85 | + |
| 146 | 53 | ( |
| 147 | 06 | 6 |
| 148 | 93 | . |
| 149 | 06 | 6 |

| | | |
|---|---|---|
| 150 | 06 | 6 |
| 151 | 06 | 6 |
| 152 | 07 | 7 |
| 153 | 52 | EE |
| 154 | 94 | +/- |
| 155 | 03 | 3 |
| 156 | 85 | + |
| 157 | 01 | 1 |
| 158 | 93 | . |
| 159 | 02 | 2 |
| 160 | 05 | 5 |
| 161 | 04 | 4 |
| 162 | 01 | 1 |
| 163 | 52 | EE |
| 164 | 94 | +/- |
| 165 | 04 | 4 |
| 166 | 65 | × |
| 167 | 43 | RCL |
| 168 | 01 | 01 |
| 169 | 75 | - |
| 170 | 01 | 1 |
| 171 | 93 | . |
| 172 | 04 | 4 |
| 173 | 00 | 0 |
| 174 | 03 | 3 |
| 175 | 09 | 9 |
| 176 | 52 | EE |
| 177 | 94 | +/- |
| 178 | 06 | 6 |
| 179 | 65 | × |
| 180 | 43 | RCL |
| 181 | 01 | 01 |
| 182 | 33 | $X^2$ |
| 183 | 85 | + |
| 184 | 05 | 5 |
| 185 | 93 | . |
| 186 | 02 | 2 |
| 187 | 00 | 0 |
| 188 | 03 | 3 |
| 189 | 02 | 2 |
| 190 | 52 | EE |
| 191 | 94 | +/- |
| 192 | 09 | 9 |
| 193 | 65 | × |
| 194 | 43 | RCL |
| 195 | 01 | 01 |
| 196 | 45 | $Y^X$ |
| 197 | 03 | 3 |
| 198 | 75 | - |
| 199 | 06 | 6 |
| 200 | 93 | . |
| 201 | 00 | 0 |
| 202 | 02 | 2 |
| 203 | 01 | 1 |
| 204 | 08 | 8 |
| 205 | 52 | EE |
| 206 | 94 | +/- |
| 207 | 01 | 1 |
| 208 | 02 | 2 |
| 209 | 65 | × |
| 210 | 43 | RCL |
| 211 | 01 | 01 |
| 212 | 45 | $Y^X$ |
| 213 | 04 | 4 |
| 214 | 54 | ) |
| 215 | 65 | × |
| 216 | 43 | RCL |
| 217 | 00 | 00 |
| 218 | 33 | $X^2$ |
| 219 | 95 | = |
| 220 | 65 | × |
| 221 | 01 | 1 |
| 222 | 00 | 0 |
| 223 | 00 | 0 |
| 224 | 00 | 0 |
| 225 | 95 | = |
| 226 | 59 | INT |
| 227 | 22 | INV |
| 228 | 57 | ENG |
| 229 | 91 | R/S |

USER INFORMATION FOR PROGRAM 9

Program: Cruise Ceiling

Number of Steps: 299

Computation Time: 11 seconds

| STEP | ENTER | PRESS KEY | DISPLAY |
| --- | --- | --- | --- |
| 1 | gross weight (lbs.) | A | gross weight/1000 |
| 2 | drag count | C | cruise ceiling |

```
000  76 LBL
001  11  A
002  55  ÷
003  01  1
004  00  0
005  00  0
006  00  0
007  95  =
008  42 STO
009  00  00
010  91 R/S
011  76 LBL
012  13  C
013  42 STO
014  01  01
015  25 CLR
016  08  8
017  05  5
018  93  .
019  01  1
020  01  1
021  08  8
022  75  -
023  93  .
024  02  2
025  09  9
026  01  1
027  01  1
028  07  7
029  65  ×
030  43 RCL
031  01  01
032  85  +
033  93  .
034  00  0
035  00  0
036  03  3
037  00  0
038  04  4
039  03  3
040  04  4
041  65  ×
042  43 RCL
043  01  01
044  33 X²
045  75  -
046  01  1
047  93  .
048  02  2
049  08  8
050  05  5
051  01  1
052  52 EE
053  94 +/-
054  05  5
055  65  ×
056  43 RCL
057  01  01
058  45 Y×
059  03  3
060  85  +
061  01  1
062  93  .
063  06  6
064  06  6
065  02  2
066  01  1
067  52 EE
068  94 +/-
069  08  8
070  65  ×
071  43 RCL
072  01  01
073  45 Y×
074  04  4
075  75  -
076  53  (
077  02  2
078  93  .
079  07  7
080  08  8
081  07  7
082  07  7
083  75  -
084  93  .
085  00  0
086  02  2
087  05  5
088  06  6
089  03  3
090  05  5
091  65  ×
092  43 RCL
093  01  01
094  85  +
095  03  3
096  93  .
097  03  3
098  00  0
099  06  6
100  03  3
101  52 EE
102  94 +/-
103  04  4
104  65  ×
105  43 RCL
106  01  01
107  33 X²
108  75  -
109  01  1
110  93  .
111  04  4
112  01  1
113  06  6
114  02  2
115  52 EE
116  94 +/-
117  06  6
118  65  ×
119  43 RCL
120  01  01
121  45 Y×
122  03  3
123  85  +
124  01  1
125  93  .
126  08  8
127  03  3
128  04  4
129  03  3
130  52 EE
131  94 +/-
132  09  9
133  65  ×
134  43 RCL
135  01  01
136  45 Y×
137  04  4
138  54  )
139  65  ×
140  43 RCL
141  00  00
142  85  +
143  53  (
144  93  .
145  00  0
146  06  6
147  03  3
148  03  3
149  02  2
```

| | | |
|---|---|---|
| 150 | 07 | 7 |
| 151 | 75 | - |
| 152 | 08 | 8 |
| 153 | 93 | . |
| 154 | 05 | 5 |
| 155 | 02 | 2 |
| 156 | 08 | 8 |
| 157 | 09 | 9 |
| 158 | 52 | EE |
| 159 | 94 | +/- |
| 160 | 04 | 4 |
| 161 | 65 | × |
| 162 | 43 | RCL |
| 163 | 01 | 01 |
| 164 | 85 | + |
| 165 | 01 | 1 |
| 166 | 93 | . |
| 167 | 00 | 0 |
| 168 | 08 | 8 |
| 169 | 01 | 1 |
| 170 | 04 | 4 |
| 171 | 52 | EE |
| 172 | 94 | +/- |
| 173 | 05 | 5 |
| 174 | 65 | × |
| 175 | 43 | RCL |
| 176 | 01 | 01 |
| 177 | 33 | X² |
| 178 | 75 | - |
| 179 | 04 | 4 |
| 180 | 93 | . |
| 181 | 06 | 6 |
| 182 | 05 | 5 |
| 183 | 01 | 1 |
| 184 | 04 | 4 |
| 185 | 52 | EE |
| 186 | 94 | +/- |
| 187 | 08 | 8 |
| 188 | 65 | × |
| 189 | 43 | RCL |
| 190 | 01 | 01 |
| 191 | 45 | Y^X |
| 192 | 03 | 3 |
| 193 | 85 | + |
| 194 | 06 | 6 |
| 195 | 93 | . |
| 196 | 00 | 0 |
| 197 | 06 | 6 |
| 198 | 00 | 0 |
| 199 | 06 | 6 |
| 200 | 52 | EE |
| 201 | 94 | +/- |
| 202 | 01 | 1 |
| 203 | 01 | 1 |
| 204 | 65 | × |
| 205 | 43 | RCL |
| 206 | 01 | 01 |
| 207 | 45 | Y^X |
| 208 | 04 | 4 |
| 209 | 54 | ) |
| 210 | 65 | × |
| 211 | 43 | RCL |
| 212 | 00 | 00 |
| 213 | 33 | X² |
| 214 | 75 | - |
| 215 | 53 | ( |
| 216 | 06 | 6 |
| 217 | 93 | . |
| 218 | 00 | 0 |
| 219 | 04 | 4 |
| 220 | 06 | 6 |
| 221 | 08 | 8 |
| 222 | 52 | EE |
| 223 | 94 | +/- |
| 224 | 04 | 4 |
| 225 | 75 | - |
| 226 | 09 | 9 |
| 227 | 93 | . |
| 228 | 00 | 0 |
| 229 | 08 | 8 |
| 230 | 02 | 2 |
| 231 | 06 | 6 |
| 232 | 52 | EE |
| 233 | 94 | +/- |
| 234 | 06 | 6 |
| 235 | 65 | × |
| 236 | 43 | RCL |
| 237 | 01 | 01 |
| 238 | 85 | + |
| 239 | 01 | 1 |
| 240 | 93 | . |
| 241 | 01 | 1 |
| 242 | 04 | 4 |
| 243 | 03 | 3 |
| 244 | 52 | EE |
| 245 | 94 | +/- |
| 246 | 07 | 7 |
| 247 | 65 | × |
| 248 | 43 | RCL |
| 249 | 01 | 01 |
| 250 | 33 | X² |
| 251 | 75 | - |
| 252 | 04 | 4 |
| 253 | 93 | . |
| 254 | 09 | 9 |
| 255 | 03 | 3 |
| 256 | 00 | 0 |
| 257 | 04 | 4 |
| 258 | 52 | EE |
| 259 | 94 | +/- |
| 260 | 01 | 1 |
| 261 | 00 | 0 |
| 262 | 65 | × |
| 263 | 43 | RCL |
| 264 | 01 | 01 |
| 265 | 45 | Y^X |
| 266 | 03 | 3 |
| 267 | 85 | + |
| 268 | 06 | 6 |
| 269 | 93 | . |
| 270 | 04 | 4 |
| 271 | 05 | 5 |
| 272 | 06 | 6 |
| 273 | 07 | 7 |
| 274 | 52 | EE |
| 275 | 94 | +/- |
| 276 | 01 | 1 |
| 277 | 03 | 3 |
| 278 | 65 | × |
| 279 | 43 | RCL |
| 280 | 01 | 01 |
| 281 | 45 | Y^X |
| 282 | 04 | 4 |
| 283 | 54 | ) |
| 284 | 65 | × |
| 285 | 43 | RCL |
| 286 | 00 | 00 |
| 287 | 45 | Y^X |
| 288 | 03 | 3 |
| 289 | 95 | = |
| 290 | 65 | × |
| 291 | 01 | 1 |
| 292 | 00 | 0 |
| 293 | 00 | 0 |
| 294 | 00 | 0 |
| 295 | 95 | = |
| 296 | 59 | INT |
| 297 | 22 | INV |
| 298 | 57 | ENG |
| 299 | 91 | R/S |

## APPENDIX F

### Microprocessor Program

This computer printout was reproduced on an IBM-360/67 Computer. This listing was entered by hand on an INTEL Corporation MDS-800 System, stored on a diskette, and sent to the IBM-360/67 via a high speed line.

```
         CRG      0100H
;   A7E  FERFCRMANCE CALCLLATCR USING THE 8048 SYSTEM
START:   SEL MBO
MAIN:    CALL CLRHX          ;CLR HEX BUFFER
         SEL MBO
         MOV RO,#36          ;DECIMAL FCINT MASK LOCATICN IN RESIDENT MEM
         MCV A,#00
         MCV @RC,A           ;CLEAR DECIMAL FCINT MASK
         INC RO
         MOV A,#08           ;SET CHARACTER CCUNTER
         MOV @ RO,A
         SEL MBO
         EN 1                ;ENABLE EXTERNAL INTERRUPT
         MOV RO,#36          ;RCTATE DECIMAL FOINT MASK LEFT
         MCV @ A,RO
         RL A
         MCV @ A,RC
MAIN1:   SEL MBO             ;GET CHARACTER
         CPL FC
         JFO HEXDG
         CALL CLRHX          ;CLEAR HEX BUFFER
         SEL MBO
         JMP MAIN1
HEXDG:   CALL HEXFL          ;SHIFT TO HEX BUFFER
HEXDG1:  MOV R7,#08          ;SET COUNTER
         MOV R1,#35          ;LOCATION OF HEX BUFFER
         MOV RO,#3F          ;LCCATICN OF DISPLAY BIT FATTERN
         SEL MBO
         JMP MAIN1

CLRHX:   MOV RO,#32          ;CLEAR HEX BUFFER
         MCV R2,#04          ;SET COUNTER
         CLR A
CLRHX1:  MCV @RO,A
         INC RO
         DJNZ R2, CLRHX1
         RET
HEXFL:   MCV RO,A            ;IF E GO TO BCDBIN
         XRL A,#0E
         JZ BCDBIN
         MOV A,RC            ;IF D, GO TO FL1
         XRL A,#0D
         JZ FL1
         MCV A,RO
         CPL A
         ADD A,#0A           ;CHECK IF ABCF, IF SO GC CN TO MAIN
         CPL A
         JNC MAIN
```

```
         ADD A,#CA
         MOV R1,#32          ;HEX BUFFER LOCATION
         MOV R2,#04          ;SET COUNTER
HEXFL1:  XCH A,@ R1
         SWAP A
         XCHD A,@ R1
         XCH A,@ R1
         INC R1
         DJNZ R2, HEXFL1
         RET
FL1:     CLR F1              ;PUT 80 IN DP MASK
         SET F1
         MOV R0,#36
         MOV @R0,#80
         RET
BCDBIN:  CALL CONV           ;CALL BCD TO BINARY CONVERSION ROUTINE
         JMP COMPUTE         ;CALL COMPUTATIONAL ROUTINE
                             ;COEFFICIENT STORAGE(BINARY FLOAT PT FORMAT)
         82                  ;B0 EXPONENT
         51                  ;B0 MOST SIGNIF BYTE
         23                  ;B0 LEAST SIGNIF BYTE
         72                  ;B1 EXPONENT
         E3                  ;B1 MOST SIGNIF BYTE
         4E                  ;B1 LEAST SIGNIF BYTE
         67                  ;B2 EXPONENT
         DD                  ;B2 MOST SIGNIF BYTE
         BA                  ;B2 LEAST SIGNIG BYTE
                             ;THIS IS  BEGINNING OF THE EXEC ROUTINE WHICH
                             ;COMPUTES  POLYNOMIAL FROM STORED COEFFICIENTS
                             ;AND A VARIABLE('X') ENTERED AT THE KEYBOARD
         CALL CTCY           ;MOVE ENTERED VARIABLE INTO X-POSITION
         MOV A,#76
         MOVP A,@A
         MOV A,#24           ;MOVE FIRST COEFFICIENT (B2) INTO Y-LOCATION
         MOV @R0,A
         MOV A,#77
         MOVP A,@A
         DEC R0
         MOV @R0,A
         MOV A,#78
         MOVP A,@A
         DEC R0
         MOV @R0,A
         CALL BIMULT         ;CALL BINARY MULT ROUTINE- MULTIPLIES NUMBERS
                             ;IN THE X-LOCATION AND Y-LOCATION TOGETHER
         MOV A,#73           ;MOVE SECOND COEFFICIENT(B1) TO THE Y-LOCATION
         MOVP A,@A
         MOV R0,#27
```

```
        MOV @RO,A
        MOV A,#74
        MOVP A,@A
        DEC RO
        MOV @RO,A
        MOV A,#75
        MOVP A,@A
        DEC RO
        MOV @RO,A
        CALL ADD          ;ADD B2*X TO B1 BY CALLING BINARY FLOATING
                          ;POINT ADDITION ROUTINE
        CALL CTOY         ;MOVE ENTERED VARIABLE INTO Y-LOCATION(AGAIN)
        CALL BIMULT       ;MULTIPLY (B2*X+B1)*X TO GET (B2*X*X)+(B1*X)
        MOV A,#70         ;MOV B0 INTO Y-LOCATION
        MOVP A,@A
        MOV RO,#27
        MOV @RO,A
        MOV A,#71
        MOVP A,@A
        DEC RO
        MOV @RO,A
        MOV A,#72
        MOVP A,@A
        DEC RO
        MOV @RO,A
        CALL ADD          ;ADD ((B2*X*X)+(B1*X)) TO B0 FOR FINAL RESULT
                          ;OF THIS POLYNOMIAL CALCULATION--NOTE THAT
                          ;WITH AN EXTENDED EXECUTIVE ROUTINE AND EXTRA
                          ;COEFFICIENT STORAGE SPACE, ANY NUMBER OF
                          ;MATHEMATICAL OPERATIONS ARE POSSIBLE
        JMP BINBCD        ;USE BINARY TO BCD CONVERSION ROUTINE
CTOY:   MOV RO,#2A        ;MOVES DESIGNATED COEFFICIENT TO Y-LOCATION
        MOV R1,#27
        MOV A,@RO
        MOV @R1,A
        DEC RO
        DEC R1
        MOV A,@RO
        MOV @R1,A
        DEC RO
        DEC R1
        MOV A,@RO
        MOV @R1,A
        RET

                          ;THIS ROUTINE CONVERTS A BINARY NUMBER
                          ;TO BINARY CODED DECIMAL(IN PREP FOR DISPLAY)
BINBCD: CALL CLR          ;CLEAR REGISTERS RO-R7
```

```
          MOV R1,#24
          MOV A,@R1
          ADD A,#69
          CPL A
          MOV R0,A
          DEC R1
          MOV A,@R1
          ORL A,#80
          MOV R5,A
          DEC R1
          MOV A,@R1
          MOV R6,A
          MOV R1,#0C
FPB1:     CALL RSHIFT
          DJNZ R0,FPB1
          CALL IBCD
          JMP MOV
CLR:      MOV R0,#07          ;CLEARS REGISTERS R0-R7
CLRR:     MOV @R0,#C0
          DEC R0
          MOV A,@R0
          JNZ CLRR
          RET
MOV:      MOV R0,#07          ;MOV REGISTERS R4-R7 TO R32-R35
          MOV R1,#35
FDPMASK:MOV@A,R0
          MOV @R1,A
          DEC R0
          MOV A,R0
          XRL A,#03
          JZ GO               ;GO TO DISPLAY ANSWER ROUTINE
          DEC R1
          CALL FDPMASK
GO:       JMP SPACE           ;JUMP TO PAGE 2 FOR ADDITIONAL SPACE
                              ;************************************************
                              ;END PAGE 0
                              ;************************************************
                              ;THIS  ROUTINE  ADDS TWO BINARY FLOATING
                              ;POINT NUMBERS.  TO CALL AND USE THIS ROUTINE,
                              ;THE NUMBERS  MUST BE IN THE X-LOCATION AND
                              ;Y-LOCATION IN THE BINARY STORAGE CONVENTION
ADD:      CALL FIXCON         ;CHANGES NUMBERS FROM STORAGE CONVENTION TO
                              ;WORKING CONVENTION
          CALL FIXEXP         ;EQUATES EXPONENTS SO NUMBERS MAY BE SUMMED
          CALL SUM            ;THIS ROUTINE SUMS THE BINARY NUMBERS TOGETHER
                              ;AND ENSURES ANSWER IS IN WORKING CONVENTION
          CALL RESTORE        ;CHANGES ANSWER BACK TO STORAGE CONVENTION AND
                              ;ENSURES NUMBER MOVED TO  STORAGE LOCATION
```

```
         RET
                              ;THIS ROUT MULTIPLIES 2 BINARY FLOATING POINT
                              ;NUMBERS.  TO CALL AND USE THIS ROUTINE,
                              ; NUMBERS TO BE MULTIPLIED TOGETHER MUST BE IN
                              ; X-LOCATION AND Y-LOCATION IN BINARY STORAGE
                              ;CONVENTION
BIMULT:  CALL FIXCON          ;CHANGES NUMBERS FROM STORAGE CONVENTION TO
                              ;WORKING CONVENTION
         CALL MULT            ; MULTIPLIES BINARY NUMBERS TOGETHER AND
                              ;ADDS EXPONENTS,AND ENSURES NUMBER IS RETURNED
                              ;TO WORKING CONVENTION
         CALL RESTORE         ;RESTORES ANSWER BACK TO STORAGE CONVENTION
                              ;AND ENSURES IT IS MOVED TO THE PROPER STORAGE
                              ;LOCATION
         RET
FIXCON:  MOV  RO,#23
         MOV  R1,#26
XSIGN:   MOV  A,@RO           ;MOVE MSB INTO ACCUMULATOR
         RLC  A               ;ROTATE MSBIT INTO CARRY
         JNC  XPOS
XNEG:    CLR  FO              ;IF CARRY SET,X IS -:THEREFORE SET FO FLAG
         CPL  FO
         JMP  XVAL
XPOS:    CLR  FO              ;X IS POSITIVE:THEREFORE CLEAR FO FLAG,
XVAL:    CLR  C               ;SET CARRY,ROTATE 1 INTO'UNDERSTOOD'MSBIT OF X
         CPL  C
         RRC  A               ;RESTORE INTO X, NOW IN WORKING CONVENTION
         MOV  @RO,A
YSIGN:   MOV  A,@R1           ;DO THE SAME FOR Y, EXCEPT USE THE F1 FLAG
         RLC  A
         JNC  YPOS
YNEG:    CLR  F1
         CPL  F1
         JMP  YVAL
YPOS:    CLR  F1
YVAL:    CLR  C
         CPL  C
         RRC  A
         MOV  @R1,A
         RET
SHIFTX:  MOV  A,@RO           ;THIS SUBROUTINE SHIFTS RIGHT WITH CARRY THE
         RRC  A               ;NUMBER SPECIFIED BY RO A NUMBER OF TIMES
         MOV  @RO,A           ;SPECIFIED BY R1
         DEC  RO
         DJNZ R1,SHIFTX
         RET
FIXEXP:  CLR  C               ;THIS SUBROUTINE ADJUSTS THE EXPONENT OF THE
         MOV  RO,#24          ;SMALLER OF 2 NUMBERS(X OR Y)SO  THE EXPONENTS
```

```
          MOV R1,#27          ; EQUAL AND THE NUMBER IS SHIFTED THE PROPER
          MOV A,@R0           ;NUMBER OF TIMES
          CPL A
          ADD A,@R1
          JC XLTY
          CPL A
          JZ XEQY
XGTY:     MOV R7,A
          ADD A,@R1
          MOV R1,A
YAGIN:    MOV R1,#26
SHIFTY:   MOV A,@R1
          RRC A
          MOV @R1,A
          DEC R1
          MOV A,@R1
          RRC A
          MOV @R1,A
          CLR C
          DJNZ R7,YAGIN
          JMP XEQY
XLTY:     CLR C
          MOV A,@R1
          CPL A
          ADD A,@R0
          CPL A
RCTX:     MOV R7,A
          ADD A,@R0
          MOV @R0,A
XAGIN:    MOV R1,#04
          MOV R0,#23
          CALL SHIFTX
          CLR C
          DJNZ R7,XAGIN
XEQY:     MOV R0,#24
          MOV A,@R0
          MOV R6,A
          RET
                              ;THIS ROUTINE ADDS TWO BINARY NUMBERS THAT ARE
                              ;IN WORKING CONVENTION
SUM:      JF0 CHECKY          ;CHECK SIGNS OF ADDENDS
          JF1 X+Y-
ALLPOS:   CALL BINADD         ;IF BOTH ARE +, ADD THE NUMBERS TOGETHER AND
          CLR F0              ;CLEAR F0( +ANSWER).  IF ANY CARRY, SHIFT,
          JNC REG1            ; RAISE EXP AS NECESSARY TO REMAIN IN WORKING
          CALL SHIFTR         ;CONVENTION
          CALL EXPADD
          JMP FINISH
```

```
REG1:    MOV R5,A
         JMP FINISH
CHECKY:  JF1 ALLNEG
X-Y+:    CALL CPLY            ;IF ONLY X IS NEGATIVE, COMPLEMENT Y AND CALL
         CALL SUB             ;SUBTRACTION ROUTINE
         JMP FINISH
X+Y-:    CALL CPLX            ;IF ONLY Y IS NEGATIVE, COMPLEMENT X AND CALL
         CALL SUB             ;SUBTRACTION ROUTINE
         JMP FINISH
ALLNEG:  CLR F0               ;IF BOTH NUMBERS  -, SET F0 FLAG(-ANSWER)
         CPL F0               ;AND ADD NUMBERS
         CALL BINACD
         JNC REG1
                              ;IF  CARRY, SHIFT, AND RAISE EXP AS NECESSARY
         CALL SHIFTR          ;TO REMAIN IN WORKING CONVENTION
         CALL EXPACD
FINISH:  RET
SUB:     JF1 REGSUB
         CALL FIXY            ;SEE 'FIXY:'FOR EXPLANATION
REGSUB:  CALL BINACD          ;ADD PREPREPARED NUMBERS> IF NO CARRY,ANSWER+
         JNC REG2             ;IF CARRY, ANSWER- AND MUST ADD BORROW TO SUM
         CLR F0               ;AND SET F0 FLAG
         CPL F0
         MOV R5,A
         CALL NEGACD
         JMP FINI
REG2:    MOV R5,A
         CLR F0
         CALL CPLR            ;IF ANSWER+, COMPLEMENT ANSWER AND CLEAR F0
FINI:    RET
BINACD:  CLR C                ;ADD BINARY NUMBERS THAT ARE IN X AND Y
         MOV R0,#20           ;LOCATIONS IN RESIDENT DATA MEMORY
         MOV R1,#25           ;LEAVE ANSWER IN ACCUMULATOR, R4, R3, R2
         MOV A,@R0            ;BYTE POSITIONS___   MSB              LSB
         MOV R2,A
         INC R0
         MOV A,@R0
         MOV R3,A
         INC R0
         MOV A,@R0
         ADD A,@R1
         MOV R4,A
         INC R0
         INC R1
         MOV A,@R0
         ADDC A,@R0
         RET
EXPACD:  MOV A,R6             ;INCREASE EXPONENT(REGISTER 6) BY 1
```

```
        ADD  A,#C1
        MOV  R6,A
        RET
SHIFTR: RRC  A              ;WITH MSB IN ACCUMULATOR, ROTATE ANSWER RIGHT
        MOV  R5,A
        MOV  A,R4           ;ANSWER POSITIONED NOW AS FOLLOWS
        RRC  A              ;R6   R5   R4   R3   R2
        MOV  R4,A           ;EXP  MSB            LSB
        MOV  A,R3
        RRC  A
        MOV  R3,A
        MOV  A,R2
        RRC  A
        MOV  R2,A
        RET
NEGACC: MOV  A,R2           ;ADD BORROW TO ANSWER
        ADDC A,#00
        MOV  R2,A
        MOV  A,R3
        ADDC A,#00
        MOV  R3,A
        MOV  A,R4
        ADDC A,#00
        MOV  R4,A
        MOV  A,R5
        ADDC A,#00
        MOV  R5,A
        RET
CPLX:   MOV  R0,#20         ;COMPLEMENT X
        MOV  R7,#04
NEXT1:  MOV  A,@R0
        CPL  A
        MOV  @R0,A
        INC  R0
        DJNZ R7,NEXT1
        RET
CPLY:   MOV  R1,#25         ;COMPLEMENT Y
        MOV  R7,#02
NEXT2:  MOV  A,@R1
        CPL  A
        MOV  @R1,A
        INC  R1
        DJNZ R7,NEXT2
        RET
EXPNEG: MOV  A,R6           ;SUBTRACT 1 FROM EXPONENT(REGISTER 6)
        CPL  A
        ADD  A,#01
        CPL  A
```

```
        MOV R6,A
        RET
                        ;*******************************************
                        ;END OF PAGE 1
                        ;*******************************************
CLRX:   MOV R1,#20      ;INITIALIZE X-LOCATION FOR CLEAR ROUTINE
        MOV R2,#05
        CALL CLEAR
        CLR F0
        RET
CLRY:   MOV R1,#25      ;INITIALIZE Y-LOCATION FOR CLEAR ROUTINE
        MOV R2,#03
        CALL CLEAR
        CLR F1
        RET
FIXY:   CLR C           ;THIS ROUTINE IS USED IN (Y-X) OPERATIONS
        MOV R0,#20      ;AND MAKES ALLOWANCE FOR ONLY 2-BYTE SIZE OF Y
        MOV A,@R0       ;BY ADDING FF(COMPLEMENT OF 00) TO THE 2 LEAST
        ADD A,#FF       ;SIGNIFICANT BYTES OF X
        MOV @R0,A
        INC R0
        MOV A,@R0
        ADDC A,#FF
        MOV @R0,A
        INC R0
        MOV A,@R0
        ADDC A,#0C
        MOV @R0,A
        INC R0
        MOV A,@R0
        ADDC A,#00
        MOV @R0,A
        RET
MULT:   CALL ROUNCX     ;ROUND  NUMBER IN X-LOCATION TO 2-BYTE NUMBER
        MOV R7,#1C
        MOV R0,#24      ;ADD EXPONENTS OF MULTIPLICATION FACTORS
        MOV R1,#27      ;(BIAS OF EXPONENT IS 7F)
        ADD A,@R0
        ADD A,#80
        JNC NOBOR
        ADDC A,#00
        ADD A,@R1
EXP:    MOV R0,#24
        MOV R6,A        ;MOVE EXPONENT SUM INTO EXPONENT REGISTER(R6)
SETREG: CALL EXPADD     ;ADD 1 TO EXPONENT BECAUSE OF EXPECTED CARRY
        DEC R0
        DEC R1
        MOV A,@R1       ;BEGIN MULTIPLICATION
```

```
         MOV R3,A           ;MULTIPLIER IS IN   R3  R2
         DEC R1             ;                   MSB LSB
         MOV A,@R1          ;MULTIPLICAND IS IN R1  R0
         MOV R2,A           ;                   MSB LSB
         MOV A,@R0          ;ANSWER IS IN R6  R5   R4   R3   R2
         MOV R1,A           ;             EXP MSB            LSB
         DEC R0
         MOV A,@R0
         MOV R0,A
         CLR C
         CLR A
         MOV R5,A
         MOV R4,A
BMP1:    MOV A,R5
         CALL SHIFTR
         JNC BMP2
         CLR C
         MOV A,R4
         ADD A,R0
         MOV R4,A
         MOV A,R5
         ADDC A,R1
         MOV R5,A
BMP2:    DJNZ R7,BMP1
         MOV A,R5
         CALL SHIFTR
         JF0 NOWY           ;CHECK FOR SIGNS
         JF1 POSNEG
SAMSIN:  CLR F0             ;PUT ROUNDOFF BYTE INTO ACCUMULATOR AND CHECK
         JMP OUT
NOWY:    JF1 SAMSIN:
POSNEG:  CLR F0             ;IF X AND Y HAVE SAME SIGN, PRODUCT SIGN IS +
         CPL F0             ;IF NOT, PRODUCT IS -
OUT:     RET
ROUNDX:  MOV R0,#21         ;PUT ROUNDOFF BYTE INTO ACCUMULATOR AND CHECK
         MOV A,@R0          ;FOR MSBIT BY ROTATING LEFT
         CLR C
         RLC A
         CLR A
         JNC END            ;IF CARRY SET,MUST ADD 1 TO NEXT SIGNIF BYTE
         INC R0
         ADDC A,@R0
         MOV @R0,A
         INC R0
         CLR A
         ADDC A,@R0
         MOV @R0,A
         JNC END            ;ALLOW FOR CARRYOVER INTO MSB AND INTO CARRY
```

```
        MOV R1,#01
        CALL SHIFTX          ;SHIFT AND INCREASE EXPONENT IF NECESSARY
        MOV R0,#24
        MOV A,@R0
        ADD A,#01
        MOV @R0,A
END:    MOV R0,#21
        CLR A
        MOV @R0,A
        DEC R0
        MOV @R0,A
        RET
SHIFTL: MOV A,R2             ;THIS ROUT SHIFTS REGS R2-R5 LEFT WITH CARRY
        RLC A
        MOV R2,A
        MOV A,R3
        RLC A
        MOV R3,A
        MOV A,R4
        RLC A
        MOV R4,A
        MOV A,R5
        RLC A
        MOV R5,A
        RET
RESTORE:CLR C
LOOP:   CALL EXPNEG          ;DECREMENT EXP, SHIFT LEFT UNTIL CARRY FILLED
        CALL SHIFTL
        JNC LOOP
        JF0 ZERO
        CLR C                ;FOR +NUMBER,CLR CARRY AND SHIFT ZERO RIGHT INTO
        CALL SHIFTR          ;'UNDERSTOOD' MSBIT OF MSB AND ADD EXPONENT
        CALL EXPADD
        JMP STORE
ZERO:   CALL SHIFTR          ;FOR -NUMBER, SHIFT 1 RIGHT INTO MSBIT OF MSB
        CALL EXPADD
STORE:  MOV R0,#24           ;STORE ANSWER IN ORIGINAL POSITION OF X
        MOV A,R6             ;NOW IN STORAGE CONVENTION
        MOV @R0,A
        DEC R0
        MOV A,R5
        MOV @R0,A
        DEC R0
        MOV A,R4
        MOV @R0,A
        DEC R0
        MOV A,R3
        MOV @R0,A
```

```
        DEC  R0
        MOV  A,R2
        MOV  @R0,A
        RET
CPLR:   MOV  A,R2              ;COMPLEMENT R2,R3,R4,R5
        CPL  A
        MOV  R2,A
        MOV  A,R3
        CPL  A
        MOV  R3,A
        MOV  A,R4
        CPL  A
        MOV  R4,A
        MOV  A,R5
        CPL  A
        MOV  R5,A
        RET
CLEAR:  CLR  A                 ;CLEAR SPECIFIED REGISTERS
        MOV  @R1,A
        INC  R1
        DJNZ R2,CLEAR
        RET
CONT:   MOV  R0,#18            ;THIS ROUTINE IS CONTINUATION FROM PGE 3 WHICH
                               ;WAS NECESSARY DUE TO LACK OF SPACE
CONV1:  CALL RSHIFT
        DJNZ R0,CONV1
        MOV  R0,#23
        MOV  R1,#04
        MOV  A,#04
        CALL FTCH1
        JMP  BFP               ;THIS ROUTINE NOW RETURNS TO PAGE 3(BFP)
SPACE:  MOV  R0,#36            ;CONTINUED FROM PAGE 0
        MOV  @R0,#E0
        JMP  HEXDG1            ;BACK TO PAGE 0
NOBCR:  CPL  A
        XCH  A,R0
        MOV  A,@R1
        DEC  A
        DJNZ R0,DECA
        JMP  EXP
                               ;*****************************************
                               ;END OF PAGE 2
                               ;*****************************************
LSHFT:  CLR  C
        MOV  A,#C7             ;LOAD COUNTER
        XCH  R0,A
LSHF1:  XCH  @R0,A
        RLC
```

```
        XCH  @R0,A
        DJNZ R0,LSHF1
        XCH  R0,A
        RET
RSHFT:  CLR  C
        MOV  A,#01
RSHF1:  XCH  R0,A
        XCH  @R0,A
        RRC
        XCH  @R0,A
        INC  RC
        XCH  R0,A
        JB3  RSHF2
        JMP  RSHF1
RSHF2:  RET
FTCH1:  XCH  @R0,A
        MOV  @R1,A
        XCH  @R0,A
        DEC  R0
        DEC  R1
        DEC  A
        JNZ  FTCH1
        INC  R1
        RET
FTCH2:  XCH  @R0,A
        MOV  @R1,A
        XCH  @R0,A
        INC  RC
        DEC  R1
        DEC  A
        JNZ  FTCH2
        INC  R1
        RET
LPGT4:  MOV  A,#C5
UGT41:  CALL GT4
        INC  A
        JB3  LGT42
        JMP  UGT41
LCGT4:  MOV  A,#04
LGT41:  CALL GT4
        DEC  A
        JNZ  LGT41
LGT42:  RET
GT4:    XCH  R0,A
        XCH  @R0,A
        ADD  A,#33
        JB7  GT41
        CPL  A
```

```
        ADD A,#30
        CPL A
GT41:   JB3 GT42
        CPL A
        ADD A,#03
        CPL A
GT42:   XCH @RO,A
        XCH RO,A
        RET
UFGT7:  MOV A,#05
UGT71:  CALL GT7
        INC A
        JB3 LGT72
        JMP UGT71
LOGT7:  MOV A,#04
LGT71:  CALL GT7
        DEC A
        JNZ LGT71
LGT72:  RET
GT7:    XCH RO,A
        XCH @RO,A
        CPL A
        JB7 GT71
        ADD A,#30
GT71:   JB3 GT72
        ADD A,#03
GT72:   CPL A
        XCH @RO,A
XCH RO,A ,
        XCH RO,A
        RET
IBIN:   MOV RO,#18          ;THIS ROUTINE CONVERTS INTEGER  BCD TO
IBIN1:  CALL RSHFT          ;INTEGER BINARY
        DJNZ RO,IBIN2
        RET
IBIN2:  CALL LOGT7
        JMP IBIN1
FBIN:   MOV RO,#19          ;CONVERTS FRACTIONAL BCD TO FRACTIONAL BINARY
FBIN1:  CALL UPGT4
        DJNZ RO,FBIN2
        RET
FBIN2:  CALL LSHFT
        JMP FBIN1
IBCD:   MOV RO,#18          ;INTEGER BINARY TO INTEGER BCD
IBCD1:  CALL LSHFT
        DJNZ RO,IBCD2
        RET
IBCD2:  CALL LOGT4
```

```
        JMP IBCD1
FBCD:   MOV R0,#19        ;FRACTIONAL BINARY TO FRACTIONAL BCD
FBCD1:  CALL UPGT1
        DJNZ R0,FBCD2
        RET
FBCD2:  CALL RSHFT
        JMP FBCD1
BFP:    MOV R0,#40        ;CONTINUING FROM PAGE 2(CONT)
BFP1:   CALL LSHIFT
        JC BFP2
        DJNZ R0,BFP1
        JMP ZERO
        CALL RSHIFT
        MOV A,#2A
        XCH A,R0
        ADD A,#5E
        MOV @R0,A
BFP3:   DEC R0
        MOV A,R1
        MOV @R0,A
        DEC R0
        MOV A,R2
        MOV @R0,A
        RET
ZERO:   MOV R0,#20
        CLR A
LDHXF:  MOV @R0,A
        JMP BFP3
LDHX:   MOV R0,#32
        MOV A,#04
        MOV R1,A
        CALL FTCH2
        MOV A,@R0
LDHX1:  MOV R0,A
        JB0 RET           ;RETURN IF BIT 0 IS SET
        CALL RSHFT
        CALL RSHFT
        CALL RSHFT
        CALL RSHFT
        MOV A,R0
        RR A
        JMP LDHX1
CONVER: CALL LDHX         ;THIS ROUTINE TAKES BCD NUMBER IN HEX BUFFER,
        CALL IBIN         ;CONVERTS IT TO BINARY, PLACES IT IN STORAGE
        MOV R0,#07        ;CONVENTION, AND RELOCATES IT IN REGISTERS
        MOV R1,#23        ;2A   29   28
        CALL FTCH1        ;EXP  MSB  LSB
        CALL LDHX
```

```
MOV RO,#04
CLR A
CALL FBIN
JMP CCNT
END
            ;********************************************
            ;END CF PROGRAM
            ;********************************************
```

## LIST OF REFERENCES


. A-7E Naval Air Training Operational Procedures and Standardization Manual, NAVAIR 01-45AEE-1, 15 March 1975.

. Siegel, W.M., "Computerization of Tactical Aircraft Performance Data for Fleet Application", M.S. Thesis, Naval Postgraduate School, Monterey CA, June 1978.

. Cuthbert, R.D., Dallas TX and Koger, G.L., Monterey CA, telephone conversation of 5 February 1978.

. Hewlett Packard 9830A Calculator Instruction Manual, Hewlett Packard, 1972.

. Personal Programming, Texas Instruments Incorporated, 1977.

. Prompt-48 Microcomputer User's Manual, INTEL Corporation, 1976.

. MCS-48 Microcomputer User's Manual, INTEL Corporation, 1976.

. "MM57109 MOS/LSI Number Oriented Microprocessor", National Semiconductor Corporation, March 1977.

. Tactical Control Computer TC-2A/76 Description and Programming Manual for Computer 6870500, Computer Product Engineering, August 1976.

. Gerald, C.F., Applied Numerical Analysis, p. 284-290, Addison-Wesley, 1973.

. Wylie, C.R., Advanced Engineering Mathematics, 4th Edition, p. 153-170, McGraw Hill, 1975.

## INITIAL DISTRIBUTION LIST

| | | No. Copies |
|---|---|---|
| 1. | Defense Documentation Center<br>Cameron Station<br>Alexandria VA 22314 | 2 |
| 2. | Library, Code 0142<br>Naval Postgraduate School<br>Monterey CA 93940 | 2 |
| 3. | Department Chairman, Code 67<br>Department of Aeronautics<br>Naval Postgraduate School<br>Monterey CA 93940 | 1 |
| 4. | Professor R. Panholzer, Code 62Pz<br>Department of Electrical Engineering<br>Naval Postgraduate School<br>Monterey CA 93940 | 1 |
| 5. | Professor D.M. Layton, Code 67Ln<br>Department of Aeronautics<br>Naval Postgraduate School<br>Monterey CA 93940 | 1 |
| 6. | Director of Aviation Safety Programs, Code 034<br>Naval Postgraduate School<br>Monterey CA 93940 | 1 |
| 7. | LCDR W.M. Siegel, Code 35<br>COMLATWINGPAC<br>NAS Lemoore CA 93245 | 1 |
| 8. | LT G.L. Koger<br>435 Burlwood Drive<br>Lemoore CA 93245 | 1 |
| 9. | CDR L. Chrans, Code 3105A<br>A-7 Program Office<br>Naval Weapons Center<br>NAF China Lake CA 93555 | 1 |

Thesis
K735
c.1 Koger 178038

The development and implementation of algorithms for an A-7E performance calculator.

9 MAY 80
19 APR 82
22 JAN 86

27023
27661
30220

Thesis 178038
K735 Koger
c.1

The development and implementation of algorithms for an A-7E performance calculator.

thesK735
The development and implementation of al
3 2768 002 11697 2
DUDLEY KNOX LIBRARY